PATENT ABSTRACTS OF JAPAN

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(54) PUSH-TYPE SCHEDULING METHOD AND APPARATUS FOR MANUFACTURING SEMICONDUCTOR, PROCESS STEP PROGRAM AND MEDIUM FOR STORING THE PROGRAM

(57)Abstract:

PROBLEM TO BE SOLVED: To control a semiconductor production line, which holds works in process(WIP) with a queue prior to reentrant bottle neck process nodes of a photolithography system, etc., in the production line.

SOLUTION: Whether a clear track returning to a reentrant node or running to the outlet of a production line is utilizable after passing all process nodes following a bottle neck process node is decided for each WIP. If the clear track is utilizable, following process nodes about the WIP are reserved. The WIP is thrown in a process flow. Due to the reserved nodes in advance, a secondary bottle neck is avoided greatly in downstream process nodes. If a clear track is utilizable for two or more WIPs, one WIP to be thrown in the process flow can be selected according to a select process, based on a queue or priority order.

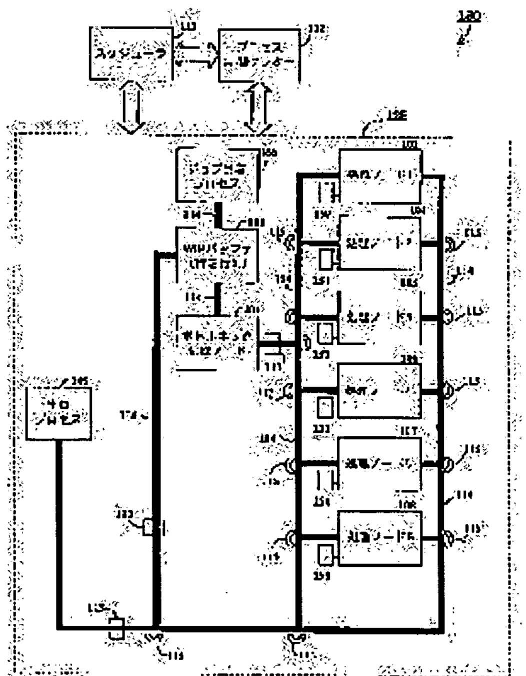

FIGURE 1A

LEGAL STATUS

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CLAIMS

[Claim(s)]
[Claim 1] The approach characterized by to have the process which reserves the processing node which follows about selected WIP when the process to judge and said clear orbit can use whether a clear orbit can use about one WIP chosen through all the processing nodes following said bottleneck processing node in the approach of controlling the production line which holds WIP to a queue in advance of a reentrant bottleneck processing node.
[Claim 2] Said bottleneck processing node is an approach according to claim 1 characterized by being a photolithography processing node.
[Claim 3] The approach according to claim 1 characterized by including further the process which starts a clear orbit about selected WIP after said processing node which follows is reserved.
[Claim 4] Said clear orbital judging is an approach according to claim 1 characterized by including the orbit which goes to the outlet of the orbit which returns to a reentrant node, or a production line.
[Claim 5] The approach according to claim 1 characterized by two or more WIP having one clear orbit.
[Claim 6] WIP chosen to said clear orbit, including further the process which starts a clear orbit about WIP chosen after said processing node which follows was reserved is an approach according to claim 5 characterized by being chosen based on a queue regulation.
[Claim 7] Said queue regulation is an approach according to claim 6 characterized by being the priority of the job in a queue.
[Claim 8] In the equipment which controls the production line which holds WIP to a queue in advance of a reentrant bottleneck processing node Memory including the field which stores the process step program which can be performed, The processor which performs the process step program in which said activation is possible is provided. The process step program in which said activation is possible (a) The process which judges whether a clear orbit can be used about one WIP following said bottleneck processing node chosen through all processing nodes, (b) Equipment characterized by including the process which reserves the processing node which follows about selected WIP when a clear orbit can be used.
[Claim 9] Said bottleneck processing node is equipment according to claim 8 characterized by being a photolithography processing node.
[Claim 10] Equipment according to claim 8 characterized by including further the process which starts a clear orbit about selected WIP after said processing node which follows is reserved.
[Claim 11] The judgment of said clear orbit is equipment according to claim 8 characterized by including the orbit which goes to the outlet of the orbit which returns to a reentrant node, or a production line.
[Claim 12] Equipment according to claim 8 characterized by two or more WIP having one clear orbit.
[Claim 13] WIP chosen to said clear orbit, including further the process which starts a clear orbit about WIP chosen after said processing node which follows was reserved is equipment according to claim 12 characterized by being chosen based on a queue regulation.
[Claim 14] Said queue regulation is equipment according to claim 13 characterized by being the priority of the job in a queue.
[Claim 15] In the process step program in which the computer activation for controlling the production line which holds WIP to a queue in advance of a reentrant bottleneck processing node is possible The process which judges whether a clear orbit can be used about one WIP chosen through all the processing nodes following said bottleneck processing node, The process step program which is characterized by including the process which reserves the processing node which follows about selected WIP when said clear orbit can be used and in which computer activation is possible.
[Claim 16] Said bottleneck processing node is a process step program which is characterized by being a photolithography processing node and in which computer activation according to claim 15 is possible.

[Claim 17] The process step program which is characterized by including further the process which starts a clear orbit about selected WIP after said processing node which follows is reserved and in which computer activation according to claim 15 is possible.
[Claim 18] Said clear orbital judging is a process step program which is characterized by including the orbit which goes to the outlet of the orbit which returns to a reentrant node, or a production line and in which computer activation according to claim 15 is possible.
[Claim 19] The process step program which is characterized by two or more WIP having one clear orbit and in which computer activation according to claim 15 is possible.
[Claim 20] WIP chosen to said clear orbit, including further the process which starts a clear orbit about WIP chosen after said processing node which follows was reserved is a process step program which is characterized by being chosen based on a queue regulation and in which computer activation according to claim 19 is possible.
[Claim 21] Said queue regulation is a process step program which is characterized by being the priority of the job in a queue and in which computer activation according to claim 20 is possible.
[Claim 22] In the medium by which the code for executing the process step program which controls the production line which holds WIP to a queue in advance of a reentrant bottleneck processing node, and in which computer activation is possible is stored and in which computer reading is possible The code for judging whether a clear orbit can be used about one WIP chosen through all the processing nodes following said bottleneck processing node, The medium which is characterized by including the code for reserving the processing node which follows about selected WIP when said clear orbit can be used and in which computer reading is possible.
[Claim 23] Said bottleneck processing node is a medium which is characterized by being a photolithography processing node and in which computer reading according to claim 22 is possible.
[Claim 24] The medium which is characterized by including further the code for starting a clear orbit about selected WIP after said processing node which follows is reserved and in which computer reading according to claim 22 is possible.
[Claim 25] Said clear orbital judging is a medium which is characterized by including the orbit which goes to the outlet of the orbit which returns to a reentrant node, or a production line and in which computer reading according to claim 22 is possible.
[Claim 26] The medium which is characterized by two or more WIP having one clear orbit and in which computer reading according to claim 22 is possible.
[Claim 27] WIP chosen to said clear orbit, including further the code for starting a clear orbit about selected WIP after said processing node which follows is reserved is a medium which is characterized by being chosen based on a queue regulation and in which computer reading according to claim 26 is possible.
[Claim 28] Said queue regulation is a medium which is characterized by being the priority of the job in a queue and in which computer reading according to claim 27 is possible.
[Claim 29] Utilization of said orbit is an approach according to claim 1 which may be an instant or is characterized by carrying out time amount reservation.
[Claim 30] Utilization of said orbit is equipment according to claim 8 which may be an instant or is characterized by carrying out time amount reservation.
[Claim 31] Utilization of said orbit is a process step program which may be an instant or is characterized by carrying out time amount reservation and in which computer activation according to claim 15 is possible.
[Claim 32] Utilization of said orbit is a medium which may be an instant or is characterized by carrying out time amount reservation and in which computer reading according to claim 22 is possible.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to control of the production line for semi-conductor manufacture. Especially this invention It is related with control of the semi-conductor production line which holds a work-in process (WIP) to a queue in front of reentrant bottleneck processing nodes (photolithography equipment etc.). This control After the processing node which is judged as the clear orbit which returns to a reentrant node through all the processing nodes following a reentrant processing node being available, and follows about the orbit is reserved, the push form approach of sending out WIP is used for the processing node which follows for processing.
[0002]
[Description of the Prior Art] Generally manufacture of a semi-conductor is performed with the reentrant production line which consists of networks of a processing node. A production line is a line where one WIP is reentrant in at least one processing node and the semantics that multiple-times processing is usually carried out by the photolithography node. Since the control to WIP included in the queue of this reentrant node is missing, a reentrant node becomes a bottleneck in a processing network in many cases. The utilization effectiveness of a production line falls by the bottleneck, and the badness of this effectiveness causes the result which increases the cost concerning the ownership of a production line, and both sides of operation.
[0003] Furthermore, the processing node following a photolithography node may reduce the effectiveness of a production line. Those consecutiveness processing nodes perform manufacture functions, such as implantation, etching, measurement processing, and oxidation treatment. Even if it adds some control to actual WIP and those consecutiveness processing nodes, a secondary bottleneck occurs in a production line and there is a possibility of causing much more degradation. In addition, effectiveness will fall further by the time amount which the re-tooling of various processors and setup in a node take.
[0004] Such non-effectiveness increases the ownership of the whole network, and cost of operation. Therefore, by lessening a secondary bottleneck, the throughput as the whole network will be improved and ownership cost will be held down to the minimum, while utilizing a bottleneck process for the maximum.
[0005] On the number of related processes, and a number of combination of relation which can consider those processes, it will become very complicated to develop the optimal schedule for such a production facility, and it is inconvenient. In case a schedule is developed, since count is complicated, adjustment on the real time over a schedule is very difficult.
[0006] This problem was solved, and some efforts have been made in order to raise the throughput of a production line. For example, the dynamic sending-out approach of the wafer lot (product) of an integrated circuit is used for U.S. Pat. No. 5,889,673 and a name "Manufacturing Method And System For Dynamic Dispatching of Integrated CircuitWafer Lots." According to this patent, the duty cycle of the equipment in the downstream of lithography equipment, i.e., descending-order equipment, is calculated, and the equipment whose presumed loading value is min is judged. Then, the highest priority is given to the equipment and a wafer lot is sent out to the equipment after a lithography process.
[0007] Therefore, the approach of U.S. Pat. No. 5,889,673 is coping with selection to which equipment to send out a product after a lithography process, in order to guarantee that loading of each equipment of the downstream is carried out appropriately. However, by this approach, it is not guaranteed that a product is processed by that equipment immediately after a product reaches the equipment of the downstream. Consequently, it is thought that a secondary bottleneck may still happen.
[0008] One attempt in which I will accept it in order to decrease a secondary bottleneck is indicated by U.S. Pat. No. 5,446,671 and the name "Look-Ahead Method For Maintaining Optimum Queued Quantities Of In-Process Parts At A

Manufacturing Bottleneck." According to this patent, the look ahead approach supervises the product currently held at the queue of all processing nodes which may serve as a bottleneck in works. It sets up a flag condition by the queue of the bottleneck process of each latency in order to prevent initiation of product migration until the management person in charge of works judges that the queue in a potential bottleneck process fell to level low enough. Thus, are recording of the product in a bottleneck queue is decreased.

[0009] However, when all processing nodes receive a product, it is not guaranteed that the approach of U.S. Pat. No. 5,446,671 as well as the case of U.S. Pat. No. 5,889,673 processes a product promptly. Therefore, the secondary bottleneck still exists only by the amount of the product in a bottleneck queue becoming less also by this approach.

[0010] It is remarkable especially in the process which manufactures a semi-conductor how it is important to cope with the problem of a bottleneck queue. Generally, in a semi-conductor manufacturing facility, a semi-conductor is manufactured with initial products, such as one wafer, this is processed through a series of processing nodes, and a completion product is formed. Each continuous processing node performs a processing task different, respectively generally. For example, in the manufacturing facility containing a series of processing nodes, each node performs monopolistically each processing of lithography, implantation, etching, measurement processing, or oxidation treatment. The processing which passes through each process is linear, and it is only 1 time that a product passes a specific process or a specific processing node. Or a series of loop formations are established and a wafer may be made to carry out the multiple-times patrol of the same processing node. A linear model is a model typical to the manufacture production line set up in the sequence that the processing node or the process was limited clearly, and, on the other hand, a loop model is a model typical to a production line whose processing node is the need according to a product and which is used by the way. If one equipment is used 2 times or more in the case of a loop model, the product which should be processed can go into the production line on a concept again.

[0011] In this invention, one of the possible processes is related with the general network of the processing node which does not have a limit in the sequence of processing required in order to complete one job, or the number of processes. Moreover, there is no limit also in the number or class of the inlet-port node in a network, or outlet node. When limiting, the path passing through the independent network which consists of n nodes is equivalent to two or more paths which cover the perfect directed graph (digraph) which has the top-most vertices of N individual, and the side of N (N-1) individual. The dynamic path which goes to another definition node from one definition node through two or more nodes is called orbit T (j, tj). j is the node set with sequence and tj is the set of the time of arrival.

[0012] Generally in a series of processing nodes, the processing node of at least one class is a bottleneck. It is [that a bottleneck exists] variously reasonable. For example, also when saying that the die length of the task which should be performed by the node may probably be longer than other processes, or the node is passed repeatedly, it thinks. Moreover, the number of those processors that the cost which operates the cost of a bottleneck processor and/or a bottleneck processor is dramatically high, therefore can adopt in a network may be restricted. Therefore, or could decrease a little the cost which operates a processing network by utilizing a bottleneck process for the maximum. That is, if the throughput of a bottleneck process is improved, the throughput as the whole network is also improved, consequently the ownership cost of the whole network will also fall. However, when the low processor of cost is not used for remainder for example, the ownership cost of the whole network is not reduced only by improving the throughput of a bottleneck process.

[0013] Many manufacture networks are finite source queuing networks which add a job to a system and go by taking into consideration the maximum number of the job in a system. Refer to explanation of "Queuing Network" (1999, Wiley, 219 pages) besides Xiuli Chen about a finite source queuing network. The bottom of such a situation can define an arrival rate as follows.

[0014]

[Formula 1]

It is lambda(n) =0 at the time of n>=M. (1)

Among a formula, when M is made into a forward integer and it is n<=M -1, lambda (n) is forward and limited. In this case, M is the number of the jobs which can hold a system. The stationary distribution of a system, i.e., the number of averages of the job in a system, is decided by the marginal distribution of the stationary distribution in the node of a system.

[0015]

[Formula 2]

$$\sum_{j=0}^{N} n_j = M \text{であるとき、} \pi(\bar{n}) = c\prod_{j=0}^{N} \pi_j(n_j) \qquad (2)$$

[0016] The stationary distribution in each node of a system which has two or more processing nodes is a poisson form mostly, therefore all the joint distributions of a processing node are also poisson forms. If a balance quotient equation is materialized by the operation system and the throughput of each node assumes by that cause that it is equal to an arrival rate, the throughput of each node can be related with the number of a queue length or jobs. If the Poisson distribution about an arrival rate are assumed, utilization factor rhoj to the node j of arbitration can be related with the number nj of averages of a job in a following formula.
[0017]
[Formula 3]

$$\rho_j = \frac{n_j}{(n_j + 1)} \qquad (3)$$

[0018] When 66% of average utilization factor is desired for every node, the number of averages of the job of each node must be 2. Therefore, in order to make a network gross mean utilization factor 66%, a network needs 2n job on an average from a formula (2). However, since the arrival to each node is a poisson process, a buffer must be able to be used by each node. For example, the chance for the queue to wait [as opposed to / when there are two jobs in each node on an average about 1/8 of time amount / in any node / four jobs] for processing, and for ten jobs to be held at a queue is 1:100.
[0019] Buffering of a product queue is a part useful when managing a network. This buffering may be realized by the central buffer according to the actual activity probability of various processing nodes. That is, a job may be returned to one buffer after processing, or buffering may be distributed to various processing nodes. The detail of distribution of a buffer is actually decided by process time amount and combination of the schedule of job processing. Constraint of the difficulty and time amount to which what kind of buffering regulation is chosen faces, and the processed job is moved is also taken into consideration. About the both sides of a straight-line model and a reentry model, allocation of this buffering and the scheduling of supply to the processing node of a product are complicated problems, and increase the processing time and a labor cost remarkably.
[0020] In a processing device, the setup time of a job assumes count of the utilization factor of the above-mentioned processing node to be what is not. That is, when it is in an idle state, a processing node can start processing promptly to the arrival time of a job. When this condition is not satisfied, the utilization effectiveness of a device falls. The same thing can be said even if it is able to take the setup time in parallel to processing of a previous job. In this case, if the number of averages of the job which stands by does not increase, utilization effectiveness falls quickly. A node must average, and must have four jobs, one of them will be under activation, and if the setup time is the same as that of the processing time, in order to acquire 60 - 70% of utilization factor, another will be set up in parallel. That is, even if it is the network in which the concurrency setup time was prepared, both a work-in process and the problem of buffering increase seriousness. The approach of generally solving these problems does not exist, needs the count put into practice for specifying the specific solution approach, and cannot be built into the cost in connection with ownership.
[0021] Therefore, buffering (namely, queue) in a bottleneck process is one process of judging the both sides of a network throughput and the capacity of a system. Therefore, reduction of network ownership cost will become easy by improvement of this process.
[0022]
[Summary of the Invention] This invention copes with the above-mentioned problem by offering control of the production line which holds a work-in process (WIP) to a queue in front of a reentrant bottleneck processing node. After this invention checks that the clear orbit which passes all processing nodes exists and reserves a clear orbit about WIP in question before returning to a reentrant processing node, or before it comes out from an outlet, it uses the push form approach of sending out WIP to the processing node which follows from a bottleneck process.
[0023] In one field, this invention may be embodied in relation to production lines, such as a semi-conductor production line. In this case, products, such as a cassette of one wafer or wafer, will wait for processing, and will be held at the queue in front of lithography. In order to use a production line more efficiently, the flow of the product which passes along a production line is controlled by judging that the clear orbit which passes along all the processing nodes following a bottleneck processing node (lithography) can be used. If a clear orbit is found out, the processing node which follows about WIP of the clear orbit and a problem will be reserved. Then, one WIP is chosen from a reentrant queue about the orbit, and an orbit is started. As for an orbit, it is desirable to include the orbit which returns to a queue or goes to the outlet of a production line.
[0024] As a result of the above actuation, WIP chosen about the orbit is processed whenever a product is received by each processing node of a production line, and it goes. Therefore, processing of a product is reserved in advance by each

node, and since it is not necessary to wait for a product to be in a condition with an available node, a secondary bottleneck is usually avoided substantially. Therefore, this invention can use a production line more efficiently and a secondary bottleneck decreases. In another field of this invention, two or more WIP authorizes starting of each orbit, and chooses one WIP based on queue regulations, such as priority of a job, from those WIP.
[0025] This invention should just be embodied with above approaches or equipment. The equipment by this invention controls the production line which holds WIP to a queue in advance of a reentrant bottleneck process. Equipment possesses the memory which stores the process step program which can be performed, and the processor which performs the process step program in which those activation is possible, and the process step program which can be performed includes reservation of the processing node in connection with the clear orbital judging corresponding to the above-mentioned approach, and its starting mostly.
[0026] The example of others of this invention contains the medium by which the code for executing the process step program in which computer activation is possible, or the process step program in which computer activation is possible was stored and in which computer reading is possible. Those process step programs include the clear orbital judging and processing node reservation corresponding to an above-mentioned approach mostly.
[0027] Furthermore, in respect of being another, this invention is the approach of carrying out scheduling of the process job which consists of two or more down stream processing through the network which consists of two or more processing nodes. Before explaining this approach, while defining a bottleneck processing node, the product buffer must be in the available condition by the bottleneck node. Therefore, it first performs defining the node or node mold which is the process used in order to set up a bottleneck process in the main bottleneck process or a multi-node processing network. If a bottleneck node is defined, in order to hold a queue, a product buffer will be arranged to a bottleneck node.

[0028] One product is chosen from the queue which should be processed in order to start this approach. This product should just be chosen based on some queue regulations, such as priority of the job in a queue. However, before processing of the product by the bottleneck process starts, it judges whether the clear orbit which passes along all processing nodes required in order to process the product following a bottleneck node exists. It is whether this orbit faces to the following bottleneck processing node buffer, or to go to a network outlet. If a clear orbit is found out, the processing node which follows about the orbit will be reserved. An orbit is reserved instancy for starting or time amount reservation is carried out. After the processing node which follows is reserved, an orbit is started and processing of the selected product by the bottleneck process starts. According to the condition of processing of a product at the last, a product is returned to the queue of a bottleneck processing node, or goes to a network outlet.
[0029] Two concepts of the above approach to this invention become clear. I hear that the guaranteed path which returns to a bottleneck buffer or goes to a network outlet is reserved by the 1st, and it is in it. I hear that loading of a bottleneck process becomes more suitable, and it is in the 2nd. An approach is guaranteed [that a bottleneck process is appropriately loaded on the occasion of network overall loading, and] when guaranteeing the path which results in the buffer before a bottleneck. It guarantees that a network operates at a more efficient rate to the combination of any processors by guaranteeing that loading of the bottleneck process is carried out appropriately.
[0030] The easy outline was described so that he could understand the property of this invention easily. By referring to detailed explanation of the following desirable examples, he can understand this invention more nearly thoroughly, making it connected with an attached drawing.
[0031]
[Embodiment of the Invention] Drawing 1 A shows the multi-node processing network 130 by this invention. As shown in drawing 1 A, a network includes the network of the processing device 125 which communicates with a scheduler 111 and the process control pin center,large 112. Although a scheduler 111 is explained below at a detail, when it says simply, a scheduler 111 should just be a process step program which is included in the computer for carrying out scheduling of the flow of the product passing through a network 125 and in which computer activation is possible. As for the process control pin center,large 112, it is desirable that it is a computing system containing the software application program for controlling the flow of the product which passes along a manufacture production facility. As for an application program, it is desirable to control the flow of the product from one processing node to the next processing node in a network 125 using the feedback information offered by various computers and sensors in a network 125. It may be related with this point and the network 125 may contain the sensor (not shown) for directing the location of the product in the network 125 at the predetermined event.
[0032] Furthermore, each processing node in networks, such as the processing nodes 102-108, may possess the computer system for controlling the processing node. In drawing 1 A, the signs 150-155 in drawing express the computing system which processes the processing nodes 103-108, respectively. Each computing systems 150-155

provide the process control pin center,large 112 with feedback information. This feedback information is used in order to control the flow of the product passing through a network 125 by the process control pin center,large 112, so that it may explain further below at a detail.

[0033] The processing network 125 contains the job arrival process 100, the WIP buffer (queue) 101, and two or more processing nodes 102-108 so that drawing 1 A may show. At least one processing node is the bottleneck processing node 102. As for the job arrival process 100, it is desirable that it is a certain process which controls the flow by which a new product goes into a network.

[0034] It is sending out the new product which should process the important function of the job arrival process 100 through a network about this point to the WIP buffer (queue) 101. The process which sends out a new product to a network is explained further below at a detail. Although it is desirable to automate in the semantics that a computer controls the flow of the new product from this process 100 to the WIP buffer (queue) 101 as for the job arrival process 100, even if the process by manual operation is used for it, it does not interfere. For example, the job arrival process 100 may be a machine which needs that an operator makes passage of a new product start.

[0035] Moreover, the job arrival process 100 may offer a display which is looked at and understood that a WIP buffer (queue) should load a new product by the eye from the job arrival process 100 to an operator. the product with which this display was seen and the operator was demanded -- the WIP buffer (queue) 101 -- for example, it will load by pushing the carbon button which passes a new product.

[0036] Furthermore, the job arrival process 100 receives the feedback from the WIP buffer (queue) 101. It is desirable to communicate through central-process stations, such as the process control pin center,large 112, mutually directly [the job arrival process 100 and the WIP buffer (queue) 101] about this point. This feedback contains various factors, such as the fixed number of WIP contained in the WIP buffer 101. It judges whether using this feedback, a product with the new job arrival process 100 should be turned to the WIP buffer (queue) 101, and should be sent out. For example, the WIP buffer (queue) 101 may be set up so that 50 products may be made into a fixed limitation. When the number of the products contained in the WIP buffer (queue) 101 becomes less than 50 pieces, the job arrival process 100 sends out a new product to the WIP buffer (queue) 101.

[0037] It is in the approach of controlling the send of a new product partly. For example, all jobs may be held until it receives directions that the job arrival process 100 has few products in the WIP buffer (queue) 101 than threshold level, such as 50 etc. pieces. In this case, the WIP buffer (queue) 101 provides the job arrival process 100 with the feedback about the number of products directly, or provides a central-process station with it. A central-process station transmits the information to the job arrival process 100. Or you may judge whether the job arrival process 100 performed the periodical inquiry of the WIP buffer 101, and the number of products became less than 50 pieces. It is not concerned with which approach is adopted, but flow of the new product to the WIP buffer (queue) 101 is performed through the job arrival process 100.

[0038] If a product is supplied to the WIP buffer (queue) 101 from the job arrival process 100, one of the products in the WIP buffer (queue) 101 will be chosen, and it will be processed. The process of this selection and the detail of processing initiation of the selected product are explained below.

[0039] As shown in drawing 1 A, a network contains two or more processing nodes 102-108. In the case of a semi-conductor processing network, it is thought that those nodes contain the node of lithography, implantation, etching, measurement processing, and oxidation treatment. However, all nodes are not used among one processing of the product which returns to a WIP buffer (queue) through a network. For example, such a situation will happen, when the processing node 103 and the processing node 104 are duplicate nodes which perform the same processing facility, respectively. In such a case, what is necessary will be just to use one of the processing nodes 103, or 104 on the occasion of processing of one product. Therefore, in drawing 1 A, in order to process further, before returning to the WIP buffer (queue) 101, or before the selected product results in the outlet process 109, it will be processed by the processing nodes 102, 103, and 106.

[0040] Two or more conveyers 114 which form a production line in the network of drawing 1 A by conveying a product from one processing node to another processing node are also shown. However, it should be cautious of it not being the only means for a conveyer conveying a product from one node to another node. Probably, the product must be conveyed by human being's hand from one node to the following node, when a conveyer cannot be used about this point due to the physical distance from one processing node to another processing node.

[0041] This is the case where there is a processing node in another building etc. In this case, operators, such as a parts mover or EKUSU ** TAIDA, will convey a product from one building to another building. In such a case, if a product is received by the following processing node, probably an operator will load the product of **** to a processing node by manual operation, and will be considered with processing being made to start. Although drawing 1 A shows the

configuration in which a conveyer 114 flows into each processing node directly, this drawing is only what only expected easy ****. Actually, when processing of one product is completed by one processing node, the product moves to the following processing node needed for product processing continuously.

[0042] However, a product is not directly sent into a processing node and processing does not necessarily start promptly there. Before being rather processed by the node, as for a product, it is common that it must be set up by the node. Generally in this case, an operator needs to equip a fixture or a maintenance tool at the order which processes a product by manual operation. Furthermore, an operator has to set up a processing node by returning the set point till then to 0, and inputting the new set point. However, in order to simplify, in drawing 1 A, the product sent into each processing node is set up automatically, and it is assumed that all maintenance stations are included in the general display of each processing node.

[0043] An example of a setup process is coat/development trace mechanism (not shown) in the bottleneck processing node 102. In drawing 1 A, coat/development trace mechanism is included in the general display of the bottleneck processing node 102. When sending out a wafer from the WIP buffer 101 to the bottleneck processing node 102 first, a wafer goes into coat/development trace mechanism first, and it is covered with a resist before a wafer is exposed in a lithography process there. After being exposed in a lithography process, in order to develop a resist [finishing / exposure], a wafer goes into coat/development trace mechanism again. Therefore, a product passes a setup process first rather than goes into a lithography process directly.

[0044] The network of drawing 1 A includes further the product trace mechanism 113 and the product flow gate 115. About this point, the product trace mechanism 113 pursues the flow of the product passing through a network, and provides the process control pin center,large 112 with feedback information. Thus, the process control pin center,large 112 can maintain the condition that the product continued. Furthermore, the process control pin center,large 112 can also operate the product flow gate 115 using this trace information. About this point, based on the feedback information from a trace mechanism, the process control pin center,large 112 can flow automatically, the gate 115 can be controlled, and the flow of the product passing through a network can be adjusted.

[0045] The process control pin center,large 112 can control substantially by any sequence the flow of the product which passes along either of the processing nodes 102-108 so that drawing 1 A shows easily. The flow of a product may be the flow which returns in order to appear from a network in a node 103 at return and the last in order to process further (accepting the need) toward the processing node 106 after that toward the processing node 103 from the bottleneck processing node 102, or to process in another lithography process. Drawing 1 C is drawing having shown the orbit considered as an orbit of a product by the arrow head of two main tracks to which various nodes are connected.

[0046] it is shown in drawing 1 C -- as -- a product -- the job arrival process 100 to the WIP buffer (queue) 101 -- a passage -- the bottleneck processing node 102, the processing node 103, the processing node 104, the processing node 106, and the processing node 108 -- order -- passing -- the WIP buffer 101 -- returning -- you may have . It explains further below control of the network shown in drawing 1 C, and flowing at a detail.

[0047] In order to control a network, some network components at least need to communicate mutually. Drawing 1 B is drawing showing the configuration with which each network component can communicate through a communication network 250, respectively. A communication network 250 may be a Local Area Network (LAN). In such a system, each processing node contains a computer like the computers 150-155 shown in drawing 1 A for controlling actuation of the processing node. Thus, each processing node is programmed according to an individual, and operates according to a numerical-control process. Therefore, when it becoming available, if condition directions of a processing node, i.e., the processing node's, are using the computer which controls a processing node by communicating with the process control pin center,large 112 by processing of a job or it is under activity by whether it being in a condition available to processing and this time, and condition directions can be offered.

[0048] Furthermore, it connects with a network and a conveyer 114, the product flow gate 115, and the trace mechanism 113 also communicate with the process control pin center,large 112. By communicating with the process control pin center,large 112, these mechanisms operate automatically with the process control pin center,large 112. Therefore, the flow of a product is automatically controlled by all the processing devices in the processing network linked to a communication network.

[0049] Although drawing 1 B shows various processing devices linked to communication networks, such as LAN, the communication link of other gestalten may be used for it. For example, you may display that it finds that processing of the product in the node completed the processing node, and it is understood by the eye. This vision display may be electronic indicators, such as a flag shown to an operator or light, and an audible tone. By manual operation, a product is put on ejection from a processing setup, and he puts it on a conveyer, the operator who received this display pushes a switch by manual operation, moves a conveyer, and sends out a product to the following processing node. Therefore, if

it is made the configuration automated thoroughly, although effectiveness will become good most, as for a network, manual operation may be needed in at least a part, and this invention can be adopted also in such a system.

[0050] Drawing 2 shows an example of the flow of the product passing through a semi-conductor processing network. As shown in drawing 2 , the product is held in front of the lithography node 102 at the WIP buffer (queue) 101. In drawing 2 , the signs 125-130 in drawing express the cassette of an unsettled wafer. However, the queue may hold not the wafer contained to the cassette but the wafer according to individual. A wafer moves to the lithography node 102 from the WIP buffer (queue) 101 first. However, a wafer may not restrict entering promptly to a lithography process, but there may be a maintenance bottle for receiving a wafer in a lithography node. This is a case so that the setup by an operator's manual operation may be required. In such a case, an operator will perform the setup of a wafer for a wafer in preparation for ejection and processing from a maintenance bottle.

[0051] Before going into lithography process 102B, a product (wafer) passes coat/development trace mechanism 102A. A wafer is covered with a resist at coat/development trace mechanism 102A. After being covered with a resist, a wafer goes into lithography process 102B, and is exposed there. After exposing in a lithography process, a wafer returns to coat/development trace mechanism 102A, and is developed.

[0052] After the lithography process in the lithography node 102 is completed, a wafer is sent out to the consecutiveness processing node 103 needed with the current processing pass passing through a network. A wafer should just be processed about this point by the processing node for performing implantation, measurement processing, oxidation treatment, and/or etching. Therefore, actual processing may be performed by two or more processing nodes although drawing 2 shows only one processing node 103 as a consecutiveness processing node. Those consecutiveness nodes as well as a lithography node may have the maintenance bottle for containing the product, when the setup by an operator's manual operation is required, and a product is received by the node.

[0053] If the process which follows is completed, a product (wafer) will return to the WIP buffer (queue) 101, or will be sent to the outlet process 109. A scheduler 111 judges whether a product should be returned to the WIP buffer (queue) 101, or it should send out to the outlet process 109 according to whether the wafer needs additional lithography processing and/or consecutiveness processing or processing of a wafer is completed using the trace condition explained previously.

[0054] Drawing 3 shows one of the systems which can be used for the communication link between various components which control the production line by this invention. In drawing 3 , in order to control the flow of the product in a network, a scheduler 11 is used. A scheduler 11 should just be a process step program which was embodied in the form of the computer program and electronic instrument which can process the decision in connection with the priority of the propriety of utilization of a device, the product which should be processed, and a product, or a certain means and in which computer activation is possible.

[0055] As shown in drawing 3 , the WIP tracking system 113 communicates with a scheduler 111. This communication link should just mind a certain other means of communications through direct communication, such as a wire communication or radiocommunication, through a Local Area Network as stated previously. As explained in relation to drawing 2 R> 2, the WIP tracking system 113 provides a scheduler 111 with the identification information of each product by the communication link of the WIP tracking system 113 and a scheduler 111. Then, a scheduler judges the priority of a product using this information.

[0056] Moreover, the queue process 101 is also communicating with the scheduler 111. The queue process 101 contains the product which is waiting for the processing which passes through a network. The queue process 101 provides a scheduler 111 with the information about the number of the products contained in the queue, the information about the discernment which shows which product is in a queue, and the information on others about the product in a queue. A scheduler 111 provides a queue with the directions which show that a new product should be loaded to the WIP buffer (queue) 101 from the job arrival process 100, for example while judging the priority of the product in a queue using this information.

[0057] Furthermore, a scheduler 111 emits which product of a queue from a queue, and provides the queue process 101 with the information about whether it should send out to a lithography process. Thus, a scheduler 111 and a queue 101 control the flow of the product which frequents a queue, communicating mutually.

[0058] Furthermore, the communication link with the process node 103 and a scheduler 111 is also shown in drawing 3 . The expedient top of a graphic display and drawing 3 show the communication link with one process node and scheduler 111 about this point. However, it will be thought actually that all the processing nodes in a network communicate with a scheduler 111.

[0059] Therefore, **** is expected and only one processing node is explained here. The processing node 103 communicates with a scheduler 111, and directs the timing expected as the propriety of utilization of the processing

node at the event of arbitration, the change in the available condition of a processing node from a utilization impossible condition, or a processing node changing from a utilization impossible condition to an available condition. As previously stated in relation to drawing 1 B, the communication link of the condition of a processing node should just be performed through other means of a certain for transmitting change of a Local Area Network, a visual signal, or a condition.

[0060] According to this invention, it can judge whether the clear orbit of whether it returns to a queue through all the processing nodes following a bottleneck processing node by the communication link with a processing node and a scheduler or to come out from a network can be used. In order that a scheduler 111 may perform this judgment, a scheduler 111 acquires the feedback information in connection with the available condition of a processing node from a processing node. As mentioned above, a processing node offers as feedback the time frame expected as the change in the available condition in connection with whether those processing nodes are available from information and a utilization impossible condition or a processing node becoming available at the event. a ****** [that all the processing nodes demanded in order that a scheduler 111 may process one product in a queue using this information are available in the orbit of that product passing through a network at that event] -- or it can judge when a processing node becomes available about an orbit.

[0061] Furthermore, if a scheduler 111 discovers a clear orbit about one product, the processing node in connection with the orbit will be reserved inside a scheduler 111. In order to process a specific product with the scheduler "which reserves the processing node in connection with an orbit", it is the semantics of reserving each processing node in a clear orbit. Thus, if an orbit is started, in order to process the selected product, each processing node is reserved. In order to emit directions of reservation, a scheduler 111 does not have to carry out direct communication to each processing node.

[0062] An orbit may be used promptly and time amount reservation may be carried out as stated briefly previously. namely, a clear orbit -- it can use -- the orbit -- promptly -- you may start (for example, it is not [be / it] under activity because of processing of product with an another lithography node) -- the orbit is started when a scheduler 111 judges. On the other hand, although the scheduler 111 discovered the clear orbit, since one of the nodes is processing another product for example, at the event, when an orbit cannot be started promptly, it should just carry out time amount reservation of the orbit. When "carrying out time amount reservation" and the node which cannot be used becomes [the] available, it is the semantics that an orbit can be reserved so that it can start at future ones of the events.

[0063] Furthermore, drawing 3 also shows the communication link with a scheduler 111 and a process control system 112. As previously explained in relation to drawing 1 A, one function of a process control system 112 is controlling the flow of the product which goes to another processing node from one processing node through a network. Therefore, if it becomes the time amount which should start an orbit behind when a scheduler 111 discovers a clear orbit and reserves a processing node, a scheduler 111 will issue directions so that an orbit may be started to a process control system 112, and, thereby, a process control system 112 will control the motion and processing of a product passing through a network.

[0064] Drawing 4 shows one example of the communication link between various parts of the processing network by this invention, and the flow of a product. By drawing 4 R> 4, a continuous line shows the flow of a product, and a dotted line shows a communication link by it. First, a product is held until it flows to a queue 101 and a clear orbit is discovered there, as it held in the job arrival process 100 and being previously explained in relation to drawing 1 A. About this point, a scheduler 111 is performed, as the clear orbital judging was previously explained in relation to drawing 3 . That is, the processing node 103 which follows communicates with a scheduler 111, and offers the available or impossible condition 166 of each node. If a scheduler 111 discovers a clear orbit about at least one product of a queue using the condition of a processing node, a scheduler 111 will reserve the processing node which the orbit follows.

[0065] Then, when an orbit should be started, a scheduler 111 supplies the signal 168 for starting an orbit to a queue 101. On the other hand, for example, since the clear orbit was judged based on the propriety of utilization of the processing node at the future event, when it is impossible to start an orbit promptly, a scheduler 111 transmits the signal 168 which shows when motive time amount is reached to a queue 101.

[0066] If an orbit is started, a product will flow from a queue 101 to the reentrant process 102. Also in this case, in a semi-conductor production line, a reentrant process may be a lithography process. If the reentrant process 102 completes processing of a product, a product will flow to each of the consecutiveness processing node 103 needed in order to process the product. By drawing 4 , in order to simplify, the processing node 103 which follows is shown as one process. However, the processing nodes 103 which follow may be multiple processes like the case of explanation of drawing 2 .

[0067] After being processed by the processing node 103 which follows, according to the orbit judged about the product

by the scheduler 111, it is decided how a product will flow. In case a clear orbit is judged about this point, a scheduler 111 judges whether it should return to a queue for an orbit's additional processing of a product, or the product is completed.
[0068] Whenever one product is completed, in order to pursue the number of processing pass, a scheduler receives feedback information from a WIP trace mechanism, as previously explained in relation to drawing 3 . A scheduler 111 can judge whether a product is completed after whether it is the last pass with which the present orbit passes along a network, and its pass, or the product needs additional processing using this information. When a scheduler 111 judges with an orbit being the last pass after being processed by the processing node 103 which follows, a product flows to the outlet process 109. On the other hand, when a scheduler 111 judges with the orbit needing additional processing, as for not the last pass but a product, a product returns to a queue 101, after being processed by the processing node 103 which follows.
[0069] Drawing 5 is a flow chart which shows the process step program for controlling the production line by this invention. The process step program of drawing 5 should just be embodied as a certain means of the others which can operate a computer program, electronic instruments, or those process step programs. It reads by computers, such as the scheduler 111 of drawing 1 A, and it is desirable to store a process step program in the medium in which computer reading is possible so that it can perform.
[0070] If it says simply, a process step program will perform a clear orbital judging, will reserve the processing node in connection with a clear orbit, and will start an orbit.
[0071] A process starts by loading a product to the queue of a reentrant process. As shown in drawing 5 , at step S501, it judges whether a queue is full. This judgment makes it connected with a number of a product of fixed limitations which can exist in a queue at the event of arbitration, and may be performed by taking into consideration the property of queues, such as the number of the products in the instant size of a queue, i.e., a queue.
[0072] For example, a fixed limitation is assigned to a queue based on the maximum number of the product which can hold a queue. A process judges the number of the products in a queue, and compares it with a fixed limitation. When judgment that a queue is full is made, flow progresses to step S503. On the other hand, when judgment that a queue is not full is made, it is step S502 and a new product is added to a queue. A new product is added to a queue until the size of a queue exceeds a fixed limitation. When a fixed limitation is arrived at, count of the orbit about the product of a queue is performed so that it may explain further below at a detail.
[0073] Orbital count relates to some steps which contain S505 from step S503. At step S503, which processing node judges whether it is in an available condition so that drawing 5 may show. The method of performing this judgment is considered variously. For example, in order to judge whether each processing node is available, a repetitive porin group may be performed with a scheduler. Or as previously stated in relation to drawing 3 and drawing 4 , each processing node may provide a scheduler with feedback information periodically about the condition of the propriety of the utilization. In order to direct the propriety of utilization, it is not concerned with which approach is used, but a judgment process continues until at least one processing node becomes available.
[0074] If at least one processing node becomes available, the processing node which is in an available condition will be classified based on the priority in a processing network, respectively (step S504). For example, being needed for processing rather than any of other nodes may classify a processing node based on which node it is. As an example, the case where both the processing nodes 103 and 104 of drawing 1 C are available is considered. In a processing network, the product which needs processing by the processing node 104 must be first processed by the processing node 103.
[0075] Therefore, since the processing node 103 must be used first, priority higher than the processing node 104 is given to the processing node 103. A scheduler classifies a processing node based on the priority of those processing nodes in a processing network whenever the directions about when each processing node will be in an available condition whenever one processing node becomes available are issued.
[0076] After classifying an available processing node, it judges which product has consistency in an available processing node among the products contained in a queue (step S505). That is, it judges whether a processing node available for the processing in the following pass whose product of which passes along a network among the products of a queue is needed.
[0077] For example, suppose that the processing nodes 103 and 104 are available. Adjustment is found out when processing only by the processing node 103 and/or the processing node 104 is being demanded with the following pass one which is contained in a queue of whose products passes along a network. However, although the processing nodes 103 and 104 are available, since the processing node 106 cannot be used when processing by the processing nodes 103, 104, and 106 is being demanded with the following pass each product of whose of a queue passes along a network, adjustment is not found out.

[0078] As mentioned above, this invention discovers the clear orbit through all the processing nodes demanded in order to process the selected products including a reentrant processing node with the following pass passing through a network. Therefore, adjustment will be found out if at least one of the processing nodes demanded in order to process the selected product cannot be used. When adjustment is found out, flow progresses to step S506. However, when adjustment is not found out, a porin group is performed again and the classifications of an available processing node based on priority including the processing node considered to have become available after the previous porin group are repeated.

[0079] Also in this case, the judgment for adjusting an available processing node with the product in a queue at step S505 is performed. When a porin group continues until adjustment was found out, and adjustment is found out, flow progresses to step S506. When at least one adjustment is found out, the product of a queue with which adjustment was found out is classified according to step S506 based on the priority. That is, when two or more adjustment is found out, a scheduler assigns priority to each product with which adjustment was found out. This priority may be based on which product is the closest to completion, i.e., which product is the closest to a network outlet?.

[0080] Then, it chooses about the orbit which passes along each of the processing node demanded in the product which has the highest priority in order to process the product with the following pass (S507), and returns to a queue, or takes out from a network.

[0081] After a product is chosen about an orbit at step S507, at step S508, the processing node demanded in order to process the selected product is reserved about the orbit. A scheduler reserves each processing node in connection with the orbit of the product chosen in the interior. A processing node may be reserved about an orbit instancy and time amount reservation may be carried out about an orbit. It is decided by whether it becomes available about an orbit by (t) at the event of whether in order for whether an orbit is used immediately or time amount reservation is carried out to start the orbit, a processing device can be used promptly, and either of the futures [device / processing].

[0082] Next, priority is given to a reentrant processing node at step S509. A reentrant processing node may give priority based on the result of a request. For example, two or more lithography equipments are contained in the network, and in order that each equipment may process the specific layer of a wafer, the case where the 1st is specified is considered. In this case, it is desirable to give priority to the equipment which will bring about the best result.

[0083] However, the equipment which has the highest priority is not always chosen. For example, although one equipment of other will perform a process when desired equipment cannot be used, the result is inferior to the result of a request.

[0084] At step S510, it judges whether the setup process in connection with one of reentrant processing nodes or its reentrant processing node itself is available. If either the setup process of one of reentrant nodes or a reentry process can be used, the orbit of the product chosen at step S511 will be started. When a setup process or a reentry process cannot be used, a porin group is performed again.

[0085] After starting the orbit of the product chosen at step S511, a process judges the number of the products in return and a queue again to step S501. Next, control of the specific product according to the orbit shown in drawing 1 C is explained.

[0086] In relation to this explanation, all the wafers of a queue are waiting for the 1st processing pass, namely, it is assumed that the product is not processed yet. Furthermore, it is assumed on the both sides of the time [1st] pass passing through a network, and time [2nd] pass that each wafer should be processed by the processing nodes 103, 104, 106, and 108, respectively.

[0087] When starting processing, the batch of the wafer contained by the cassette is first loaded to the job arrival process 100. For example, what is necessary is just to load cassettes 125-130 to the job arrival process 100, as shown in drawing 2 . Generally a wafer batch is loaded by the operator by manual operation.

[0088] When it returns to drawing 1 C, it is loaded in wafer batch from the job arrival process 100 until the number of sheets of the wafer with which the WIP buffer (queue) 101 is loaded to a queue using steps S501 and S502 of drawing 5 reaches a predetermined limitation, for example, ten batches. The process of this loading should just be controlled by the process control pin center,large 112. If the number of the loaded wafer batches reaches a limitation (10), it will be ordered the process control pin center,large 112 so that the job arrival process 100 may be made to stop loading of the wafer batch to a queue 101.

[0089] A scheduler 111 judges whether the clear orbit which passes along all processing nodes, and returns to a queue 101 about each of ten wafer batches of a queue 101, or comes out of a process 109 exists. As stated previously, a scheduler 111 receives the feedback information about the condition of the propriety of the utilization from each processing node 103-108.

[0090] It is not, and no processing nodes are under activity, therefore assume that all processing nodes are available in

this example. Therefore, except for the wafer in a queue 101, the wafer does not exist in a network. Therefore, since each wafer of a queue 101 is in the condition of waiting for the time [1st] processing pass passing through a network, it judges whether a scheduler 111 has the available processing nodes 103, 104, 106, and 108 for every wafer.

[0091] As mentioned above, the processing nodes 103, 104, 106, and 108 are nodes needed in order to process a wafer with time [1st] pass. If it judges with those processing nodes being available, a scheduler 111 will judge whether a clear orbit can be used about each wafer in a queue 101.

[0092] The next step of processing is a step which judges which wafer in a queue 101 a scheduler 111 should choose to a clear orbit. As previously explained in relation to drawing 5 , priority is given to a wafer based on the number of the processing steps demanded in order to complete processing.

[0093] However, in this example, since all wafers are in the condition of waiting for time [1st] processing pass, all wafers have the same priority. Therefore, a scheduler 111 chooses one sheet of the arbitration in ten wafers by choosing the wafer probably loaded to the beginning by the queue 101 from the ** job arrival process 100 on the occasion of processing.

[0094] If a scheduler 111 chooses one wafer about a clear orbit, a scheduler 111 will reserve the processing nodes 103, 104, 106, and 108 (processing node demanded in order to process the wafer chosen in the time [1st] current pass passing through a network).

[0095] If a processing node is reserved, a scheduler 111 will judge whether the bottleneck processing node 102 can be used about an orbit instancy. Since there is no wafer currently processed according to the bottleneck process 102 in this example at that event, it is possible to use an orbit instancy. Then, a scheduler 111 transmits a signal to a queue 101 and the process control pin center,large 112, in order to emit the selected wafer and to send it out to the bottleneck processing node 102 (lithography).

[0096] Next, the process control pin center,large 112 operates a queue 101, a conveyer 104, the gate 115, etc., and in order to move the selected wafer to the processing node 102, it starts control of processing.

[0097] Before going into the processing node 102, a wafer may pass the trace mechanism 113. The trace mechanism 113 may be a scanner which gets to know the serial number of the wafer by scanning the bar code of a wafer. Then, the trace mechanism 113 provides a scheduler 111 with the identification information of a wafer. A scheduler 111 assigns priority for every wafer of a queue using this information as stated previously.

[0098] As mentioned above, the bottleneck processing node 102 may need the setup by an operator's manual operation. However, in this example, the setup is automatic, and when the processing node 102 is reached, a wafer is set up automatically and assumed to be that from which a lithography process begins.

[0099] After the 1st wafer begins to be processed, a scheduler 111 calculates a clear orbital judging about each of the wafer which remains in the queue 101. In this case, since the processing nodes 103, 104, 106, and 108 are reserved, when a scheduler 111 judges [that those nodes cannot be used and], a scheduler 111 will not find out a clear orbit about every product of a queue.

[0100] However, each processing node 103, 104, 106, and 108 issues directions that those nodes become available at time amount (t) to a scheduler 111. Therefore, a scheduler 111 can find out a clear orbit to time amount (t) for every wafer of a queue 101. In this case, time amount reservation of the clear orbit is carried out. That is, a reservation signal is transmitted to each of the processing node in connection with the 2nd wafer chosen about the orbit so that each processing node may be reserved by time amount (t) about the orbit of the 2nd wafer. Therefore, if time amount (t) is reached, a scheduler 111 will transmit a signal to a queue 101, in order to start the orbit of the 2nd wafer, when the processing node 102 becomes available.

[0101] The above-mentioned process is continued a scheduler 111 calculating a clear orbital judging for every wafer of a queue. However, if the 1st wafer returns to a queue following completion of the 1st processing pass, a scheduler 111 will calculate a clear orbital judging again about the wafer of a queue including the 1st wafer. This situation is explained further below at a detail.

[0102] If the 1st wafer returns to a queue 101, a scheduler 111 will calculate a clear orbital judging the same with having explained previously. However, if the clear orbit is found out about two or more wafers of a queue 101, a scheduler 111 will reserve the orbit about the wafer which has the highest priority. In the case of this example, the 1st wafer has completed one processing pass, but no remaining wafers of a queue 101 are processed at all.

[0103] Therefore, before a scheduler 111 assigns high priority with the 1st wafer, consequently reserves a clear orbit about the low wafer of priority from it, it reserves a clear orbit about the 1st wafer. Therefore, if the processing node 102 will be in an available condition, a scheduler 111 will transmit a signal to a queue 101, in order to start an orbit about the 1st wafer.

[0104] A scheduler communicates with various processing devices of a network 125, consequently controls the flow of

the product in a processing facility so that the above example shows easily. Usually, processing of the product of a queue is not started until a clear orbital judging is found out and a processing node is reserved about the orbit. Therefore, the secondary bottleneck in a processing network is avoided substantially. Moreover, since a still more suitable loading schedule is prescribed by the scheduler, utilization of a bottleneck process is also improved greatly.
[0105] This invention was explained about the specific example. This invention is not limited to an above-mentioned example, but he should understand that various modification and deformation can be carried out without deviating from the meaning of this invention by this contractor.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to control of the production line for semi-conductor manufacture. Especially this invention It is related with control of the semi-conductor production line which holds a work-in process (WIP) to a queue in front of reentrant bottleneck processing nodes (photolithography equipment etc.). This control After the processing node which is judged as the clear orbit which returns to a reentrant node through all the processing nodes following a reentrant processing node being available, and follows about the orbit is reserved, the push form approach of sending out WIP is used for the processing node which follows for processing.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] Generally manufacture of a semi-conductor is performed with the reentrant production line which consists of networks of a processing node. A production line is a line where one WIP is reentrant in at least one processing node and the semantics that multiple-times processing is usually carried out by the photolithography node. Since the control to WIP included in the queue of this reentrant node is missing, a reentrant node becomes a bottleneck in a processing network in many cases. The utilization effectiveness of a production line falls by the bottleneck, and the badness of this effectiveness causes the result which increases the cost concerning the ownership of a production line, and both sides of operation.
[0003] Furthermore, the processing node following a photolithography node may reduce the effectiveness of a production line. Those consecutiveness processing nodes perform manufacture functions, such as implantation, etching, measurement processing, and oxidation treatment. Even if it adds some control to actual WIP and those consecutiveness processing nodes, a secondary bottleneck occurs in a production line and there is a possibility of causing much more degradation. In addition, effectiveness will fall further by the time amount which the re-tooling of various processors and setup in a node take.
[0004] Such non-effectiveness increases the ownership of the whole network, and cost of operation. Therefore, by lessening a secondary bottleneck, the throughput as the whole network will be improved and ownership cost will be held down to the minimum, while utilizing a bottleneck process for the maximum.
[0005] On the number of related processes, and a number of combination of relation which can consider those processes, it will become very complicated to develop the optimal schedule for such a production facility, and it is inconvenient. In case a schedule is developed, since count is complicated, adjustment on the real time over a schedule is very difficult.
[0006] This problem was solved, and some efforts have been made in order to raise the throughput of a production line. For example, the dynamic sending-out approach of the wafer lot (product) of an integrated circuit is used for U.S. Pat. No. 5,889,673 and a name "Manufacturing Method And System For Dynamic Dispatching of Integrated CircuitWafer Lots." According to this patent, the duty cycle of the equipment in the downstream of lithography equipment, i.e., descending-order equipment, is calculated, and the equipment whose presumed loading value is min is judged. Then, the highest priority is given to the equipment and a wafer lot is sent out to the equipment after a lithography process.
[0007] Therefore, the approach of U.S. Pat. No. 5,889,673 is coping with selection to which equipment to send out a product after a lithography process, in order to guarantee that loading of each equipment of the downstream is carried out appropriately. However, by this approach, it is not guaranteed that a product is processed by that equipment immediately after a product reaches the equipment of the downstream. Consequently, it is thought that a secondary bottleneck may still happen.
[0008] One attempt in which I will accept it in order to decrease a secondary bottleneck is indicated by U.S. Pat. No. 5,446,671 and the name "Look-Ahead Method For Maintaining Optimum Queued Quantities Of In-Process Parts At A Manufacturing Bottleneck." According to this patent, the look ahead approach supervises the product currently held at the queue of all processing nodes which may serve as a bottleneck in works. It sets up a flag condition by the queue of the bottleneck process of each latency in order to prevent initiation of product migration until the management person in charge of works judges that the queue in a potential bottleneck process fell to level low enough. Thus, are recording of the product in a bottleneck queue is decreased.
[0009] However, when all processing nodes receive a product, it is not guaranteed that the approach of U.S. Pat. No. 5,446,671 as well as the case of U.S. Pat. No. 5,889,673 processes a product promptly. Therefore, the secondary bottleneck still exists only by the amount of the product in a bottleneck queue becoming less also by this approach.
[0010] It is remarkable especially in the process which manufactures a semi-conductor how it is important to cope with

the problem of a bottleneck queue. Generally, in a semi-conductor manufacturing facility, a semi-conductor is manufactured with initial products, such as one wafer, this is processed through a series of processing nodes, and a completion product is formed. Each continuous processing node performs a processing task different, respectively generally. For example, in the manufacturing facility containing a series of processing nodes, each node performs monopolistically each processing of lithography, implantation, etching, measurement processing, or oxidation treatment. The processing which passes through each process is linear, and it is only 1 time that a product passes a specific process or a specific processing node. Or a series of loop formations are established and a wafer may be made to carry out the multiple-times patrol of the same processing node. A linear model is a model typical to the manufacture production line set up in the sequence that the processing node or the process was limited clearly, and, on the other hand, a loop model is a model typical to a production line whose processing node is the need according to a product and which is used by the way. If one equipment is used 2 times or more in the case of a loop model, the product which should be processed can go into the production line on a concept again.

[0011] In this invention, one of the possible processes is related with the general network of the processing node which does not have a limit in the sequence of processing required in order to complete one job, or the number of processes. Moreover, there is no limit also in the number or class of the inlet-port node in a network, or outlet node. When limiting, the path passing through the independent network which consists of n nodes is equivalent to two or more paths which cover the perfect directed graph (digraph) which has the top-most vertices of N individual, and the side of N (N-1) individual. The dynamic path which goes to another definition node from one definition node through two or more nodes is called orbit T (j, tj). j is the node set with sequence and tj is the set of the time of arrival.

[0012] Generally in a series of processing nodes, the processing node of at least one class is a bottleneck. It is [that a bottleneck exists] variously reasonable. For example, also when saying that the die length of the task which should be performed by the node may probably be longer than other processes, or the node is passed repeatedly, it thinks. Moreover, the number of those processors that the cost which operates the cost of a bottleneck processor and/or a bottleneck processor is dramatically high, therefore can adopt in a network may be restricted. Therefore, or could decrease a little the cost which operates a processing network by utilizing a bottleneck process for the maximum. That is, if the throughput of a bottleneck process is improved, the throughput as the whole network is also improved, consequently the ownership cost of the whole network will also fall. However, when the low processor of cost is not used for remainder for example, the ownership cost of the whole network is not reduced only by improving the throughput of a bottleneck process.

[0013] Many manufacture networks are finite source queuing networks which add a job to a system and go by taking into consideration the maximum number of the job in a system. Refer to explanation of "Queuing Network" (1999, Wiley, 219 pages) besides Xiuli Chen about a finite source queuing network. The bottom of such a situation can define an arrival rate as follows.

[0014]

[Formula 1]

It is lambda(n) =0 at the time of n>=M. (1)

Among a formula, when M is made into a forward integer and it is n<=M -1, lambda (n) is forward and limited. In this case, M is the number of the jobs which can hold a system. The stationary distribution of a system, i.e., the number of averages of the job in a system, is decided by the marginal distribution of the stationary distribution in the node of a system.

[0015]

[Formula 2]

$$\sum_{j=0}^{N} n_j = M \text{であるとき、} \pi(\bar{n}) = c\prod_{j=0}^{N} \pi_j(n_j) \qquad (2)$$

[0016] The stationary distribution in each node of a system which has two or more processing nodes is a poisson form mostly, therefore all the joint distributions of a processing node are also poisson forms. If a balance quotient equation is materialized by the operation system and the throughput of each node assumes by that cause that it is equal to an arrival rate, the throughput of each node can be related with the number of a queue length or jobs. If the Poisson distribution about an arrival rate are assumed, utilization factor rhoj to the node j of arbitration can be related with the number nj of averages of a job in a following formula.

[0017]

[Formula 3]

$$\rho_j = \frac{n_j}{(n_j + 1)} \qquad (3)$$

[0018] When 66% of average utilization factor is desired for every node, the number of averages of the job of each node must be 2. Therefore, in order to make a network gross mean utilization factor 66%, a network needs 2n job on an average from a formula (2). However, since the arrival to each node is a poisson process, a buffer must be able to be used by each node. For example, the chance for the queue to wait [as opposed to / when there are two jobs in each node on an average about 1/8 of time amount / in any node / four jobs] for processing, and for ten jobs to be held at a queue is 1:100.
[0019] Buffering of a product queue is a part useful when managing a network. This buffering may be realized by the central buffer according to the actual activity probability of various processing nodes. That is, a job may be returned to one buffer after processing, or buffering may be distributed to various processing nodes. The detail of distribution of a buffer is actually decided by process time amount and combination of the schedule of job processing. Constraint of the difficulty and time amount to which what kind of buffering regulation is chosen faces, and the processed job is moved is also taken into consideration. About the both sides of a straight-line model and a reentry model, allocation of this buffering and the scheduling of supply to the processing node of a product are complicated problems, and increase the processing time and a labor cost remarkably.
[0020] In a processing device, the setup time of a job assumes count of the utilization factor of the above-mentioned processing node to be what is not. That is, when it is in an idle state, a processing node can start processing promptly to the arrival time of a job. When this condition is not satisfied, the utilization effectiveness of a device falls. The same thing can be said even if it is able to take the setup time in parallel to processing of a previous job. In this case, if the number of averages of the job which stands by does not increase, utilization effectiveness falls quickly. A node must average, and must have four jobs, one of them will be under activation, and if the setup time is the same as that of the processing time, in order to acquire 60 - 70% of utilization factor, another will be set up in parallel. That is, even if it is the network in which the concurrency setup time was prepared, both a work-in process and the problem of buffering increase seriousness. The approach of generally solving these problems does not exist, needs the count put into practice for specifying the specific solution approach, and cannot be built into the cost in connection with ownership.
[0021] Therefore, buffering (namely, queue) in a bottleneck process is one process of judging the both sides of a network throughput and the capacity of a system. Therefore, reduction of network ownership cost will become easy by improvement of this process.
[0022]
[Summary of the Invention] This invention copes with the above-mentioned problem by offering control of the production line which holds a work-in process (WIP) to a queue in front of a reentrant bottleneck processing node. After this invention checks that the clear orbit which passes all processing nodes exists and reserves a clear orbit about WIP in question before returning to a reentrant processing node, or before it comes out from an outlet, it uses the push form approach of sending out WIP to the processing node which follows from a bottleneck process.
[0023] In one field, this invention may be embodied in relation to production lines, such as a semi-conductor production line. In this case, products, such as a cassette of one wafer or wafer, will wait for processing, and will be held at the queue in front of lithography. In order to use a production line more efficiently, the flow of the product which passes along a production line is controlled by judging that the clear orbit which passes along all the processing nodes following a bottleneck processing node (lithography) can be used. If a clear orbit is found out, the processing node which follows about WIP of the clear orbit and a problem will be reserved. Then, one WIP is chosen from a reentrant queue about the orbit, and an orbit is started. As for an orbit, it is desirable to include the orbit which returns to a queue or goes to the outlet of a production line.
[0024] As a result of the above actuation, WIP chosen about the orbit is processed whenever a product is received by each processing node of a production line, and it goes. Therefore, processing of a product is reserved in advance by each node, and since it is not necessary to wait for a product to be in a condition with an available node, a secondary bottleneck is usually avoided substantially. Therefore, this invention can use a production line more efficiently and a secondary bottleneck decreases. In another field of this invention, two or more WIP authorizes starting of each orbit, and chooses one WIP based on queue regulations, such as priority of a job, from those WIP.
[0025] This invention should just be embodied with above approaches or equipment. The equipment by this invention controls the production line which holds WIP to a queue in advance of a reentrant bottleneck process. Equipment possesses the memory which stores the process step program which can be performed, and the processor which performs the process step program in which those activation is possible, and the process step program which can be performed includes reservation of the processing node in connection with the clear orbital judging corresponding to the above-mentioned approach, and its starting mostly.

[0026] The example of others of this invention contains the medium by which the code for executing the process step program in which computer activation is possible, or the process step program in which computer activation is possible was stored and in which computer reading is possible. Those process step programs include the clear orbital judging and processing node reservation corresponding to an above-mentioned approach mostly.

[0027] Furthermore, in respect of being another, this invention is the approach of carrying out scheduling of the process job which consists of two or more down stream processing through the network which consists of two or more processing nodes. Before explaining this approach, while defining a bottleneck processing node, the product buffer must be in the available condition by the bottleneck node. Therefore, it first performs defining the node or node mold which is the process used in order to set up a bottleneck process in the main bottleneck process or a multi-node processing network. If a bottleneck node is defined, in order to hold a queue, a product buffer will be arranged to a bottleneck node.

[0028] One product is chosen from the queue which should be processed in order to start this approach. This product should just be chosen based on some queue regulations, such as priority of the job in a queue. However, before processing of the product by the bottleneck process starts, it judges whether the clear orbit which passes along all processing nodes required in order to process the product following a bottleneck node exists. It is whether this orbit faces to the following bottleneck processing node buffer, or to go to a network outlet. If a clear orbit is found out, the processing node which follows about the orbit will be reserved. An orbit is reserved instancy for starting or time amount reservation is carried out. After the processing node which follows is reserved, an orbit is started and processing of the selected product by the bottleneck process starts. According to the condition of processing of a product at the last, a product is returned to the queue of a bottleneck processing node, or goes to a network outlet.

[0029] Two concepts of the above approach to this invention become clear. I hear that the guaranteed path which returns to a bottleneck buffer or goes to a network outlet is reserved by the 1st, and it is in it. I hear that loading of a bottleneck process becomes more suitable, and it is in the 2nd. An approach is guaranteed [that a bottleneck process is appropriately loaded on the occasion of network overall loading, and] when guaranteeing the path which results in the buffer before a bottleneck. It guarantees that a network operates at a more efficient rate to the combination of any processors by guaranteeing that loading of the bottleneck process is carried out appropriately.

[0030] The easy outline was described so that he could understand the property of this invention easily. By referring to detailed explanation of the following desirable examples, he can understand this invention more nearly thoroughly, making it connected with an attached drawing.

[0031]

[Embodiment of the Invention] Drawing 1 A shows the multi-node processing network 130 by this invention. As shown in drawing 1 A, a network includes the network of the processing device 125 which communicates with a scheduler 111 and the process control pin center,large 112. Although a scheduler 111 is explained below at a detail, when it says simply, a scheduler 111 should just be a process step program which is included in the computer for carrying out scheduling of the flow of the product passing through a network 125 and in which computer activation is possible. As for the process control pin center,large 112, it is desirable that it is a computing system containing the software application program for controlling the flow of the product which passes along a manufacture production facility. As for an application program, it is desirable to control the flow of the product from one processing node to the next processing node in a network 125 using the feedback information offered by various computers and sensors in a network 125. It may be related with this point and the network 125 may contain the sensor (not shown) for directing the location of the product in the network 125 at the predetermined event.

[0032] Furthermore, each processing node in networks, such as the processing nodes 102-108, may possess the computer system for controlling the processing node. In drawing 1 A, the signs 150-155 in drawing express the computing system which processes the processing nodes 103-108, respectively. Each computing systems 150-155 provide the process control pin center,large 112 with feedback information. This feedback information is used in order to control the flow of the product passing through a network 125 by the process control pin center,large 112, so that it may explain further below at a detail.

[0033] The processing network 125 contains the job arrival process 100, the WIP buffer (queue) 101, and two or more processing nodes 102-108 so that drawing 1 A may show. At least one processing node is the bottleneck processing node 102. As for the job arrival process 100, it is desirable that it is a certain process which controls the flow by which a new product goes into a network.

[0034] It is sending out the new product which should process the important function of the job arrival process 100 through a network about this point to the WIP buffer (queue) 101. The process which sends out a new product to a network is explained further below at a detail. Although it is desirable to automate in the semantics that a computer

controls the flow of the new product from this process 100 to the WIP buffer (queue) 101 as for the job arrival process 100, even if the process by manual operation is used for it, it does not interfere. For example, the job arrival process 100 may be a machine which needs that an operator makes passage of a new product start.

[0035] Moreover, the job arrival process 100 may offer a display which is looked at and understood that a WIP buffer (queue) should load a new product by the eye from the job arrival process 100 to an operator. the product with which this display was seen and the operator was demanded -- the WIP buffer (queue) 101 -- for example, it will load by pushing the carbon button which passes a new product.

[0036] Furthermore, the job arrival process 100 receives the feedback from the WIP buffer (queue) 101. It is desirable to communicate through central-process stations, such as the process control pin center,large 112, mutually directly [the job arrival process 100 and the WIP buffer (queue) 101] about this point. This feedback contains various factors, such as the fixed number of WIP contained in the WIP buffer 101. It judges whether using this feedback, a product with the new job arrival process 100 should be turned to the WIP buffer (queue) 101, and should be sent out. For example, the WIP buffer (queue) 101 may be set up so that 50 products may be made into a fixed limitation. When the number of the products contained in the WIP buffer (queue) 101 becomes less than 50 pieces, the job arrival process 100 sends out a new product to the WIP buffer (queue) 101.

[0037] It is in the approach of controlling the send of a new product partly. For example, all jobs may be held until it receives directions that the job arrival process 100 has few products in the WIP buffer (queue) 101 than threshold level, such as 50 etc. pieces. In this case, the WIP buffer (queue) 101 provides the job arrival process 100 with the feedback about the number of products directly, or provides a central-process station with it. A central-process station transmits the information to the job arrival process 100. Or you may judge whether the job arrival process 100 performed the periodical inquiry of the WIP buffer 101, and the number of products became less than 50 pieces. It is not concerned with which approach is adopted, but flow of the new product to the WIP buffer (queue) 101 is performed through the job arrival process 100.

[0038] If a product is supplied to the WIP buffer (queue) 101 from the job arrival process 100, one of the products in the WIP buffer (queue) 101 will be chosen, and it will be processed. The process of this selection and the detail of processing initiation of the selected product are explained below.

[0039] As shown in drawing 1 A, a network contains two or more processing nodes 102-108. In the case of a semi-conductor processing network, it is thought that those nodes contain the node of lithography, implantation, etching, measurement processing, and oxidation treatment. However, all nodes are not used among one processing of the product which returns to a WIP buffer (queue) through a network. For example, such a situation will happen, when the processing node 103 and the processing node 104 are duplicate nodes which perform the same processing facility, respectively. In such a case, what is necessary will be just to use one of the processing nodes 103, or 104 on the occasion of processing of one product. Therefore, in drawing 1 A, in order to process further, before returning to the WIP buffer (queue) 101, or before the selected product results in the outlet process 109, it will be processed by the processing nodes 102, 103, and 106.

[0040] Two or more conveyers 114 which form a production line in the network of drawing 1 A by conveying a product from one processing node to another processing node are also shown. However, it should be cautious of it not being the only means for a conveyer conveying a product from one node to another node. Probably, the product must be conveyed by human being's hand from one node to the following node, when a conveyer cannot be used about this point due to the physical distance from one processing node to another processing node.

[0041] This is the case where there is a processing node in another building etc. In this case, operators, such as a parts mover or EKUSU ** TAIDA, will convey a product from one building to another building. In such a case, if a product is received by the following processing node, probably an operator will load the product of **** to a processing node by manual operation, and will be considered with processing being made to start. Although drawing 1 A shows the configuration in which a conveyer 114 flows into each processing node directly, this drawing is only what only expected easy ****. Actually, when processing of one product is completed by one processing node, the product moves to the following processing node needed for product processing continuously.

[0042] However, a product is not directly sent into a processing node and processing does not necessarily start promptly there. Before being rather processed by the node, as for a product, it is common that it must be set up by the node. Generally in this case, an operator needs to equip a fixture or a maintenance tool at the order which processes a product by manual operation. Furthermore, an operator has to set up a processing node by returning the set point till then to 0, and inputting the new set point. However, in order to simplify, in drawing 1 A, the product sent into each processing node is set up automatically, and it is assumed that all maintenance stations are included in the general display of each processing node.

[0043] An example of a setup process is coat/development trace mechanism (not shown) in the bottleneck processing node 102. In drawing 1 A, coat/development trace mechanism is included in the general display of the bottleneck processing node 102. When sending out a wafer from the WIP buffer 101 to the bottleneck processing node 102 first, a wafer goes into coat/development trace mechanism first, and it is covered with a resist before a wafer is exposed in a lithography process there. After being exposed in a lithography process, in order to develop a resist [finishing / exposure], a wafer goes into coat/development trace mechanism again. Therefore, a product passes a setup process first rather than goes into a lithography process directly.

[0044] The network of drawing 1 A includes further the product trace mechanism 113 and the product flow gate 115. About this point, the product trace mechanism 113 pursues the flow of the product passing through a network, and provides the process control pin center,large 112 with feedback information. Thus, the process control pin center,large 112 can maintain the condition that the product continued. Furthermore, the process control pin center,large 112 can also operate the product flow gate 115 using this trace information. About this point, based on the feedback information from a trace mechanism, the process control pin center,large 112 can flow automatically, the gate 115 can be controlled, and the flow of the product passing through a network can be adjusted.

[0045] The process control pin center,large 112 can control substantially by any sequence the flow of the product which passes along either of the processing nodes 102-108 so that drawing 1 A shows easily. The flow of a product may be the flow which returns in order to appear from a network in a node 103 at return and the last in order to process further (accepting the need) toward the processing node 106 after that toward the processing node 103 from the bottleneck processing node 102, or to process in another lithography process. Drawing 1 C is drawing having shown the orbit considered as an orbit of a product by the arrow head of two main tracks to which various nodes are connected.

[0046] it is shown in drawing 1 C -- as -- a product -- the job arrival process 100 to the WIP buffer (queue) 101 -- a passage -- the bottleneck processing node 102, the processing node 103, the processing node 104, the processing node 106, and the processing node 108 -- order -- passing -- the WIP buffer 101 -- returning -- you may have . It explains further below control of the network shown in drawing 1 C, and flowing at a detail.

[0047] In order to control a network, some network components at least need to communicate mutually. Drawing 1 B is drawing showing the configuration with which each network component can communicate through a communication network 250, respectively. A communication network 250 may be a Local Area Network (LAN). In such a system, each processing node contains a computer like the computers 150-155 shown in drawing 1 A for controlling actuation of the processing node. Thus, each processing node is programmed according to an individual, and operates according to a numerical-control process. Therefore, when it becoming available, if condition directions of a processing node, i.e., the processing node's, are using the computer which controls a processing node by communicating with the process control pin center,large 112 by processing of a job or it is under activity by whether it being in a condition available to processing and this time, and condition directions can be offered.

[0048] Furthermore, it connects with a network and a conveyer 114, the product flow gate 115, and the trace mechanism 113 also communicate with the process control pin center,large 112. By communicating with the process control pin center,large 112, these mechanisms operate automatically with the process control pin center,large 112. Therefore, the flow of a product is automatically controlled by all the processing devices in the processing network linked to a communication network.

[0049] Although drawing 1 B shows various processing devices linked to communication networks, such as LAN, the communication link of other gestalten may be used for it. For example, you may display that it finds that processing of the product in the node completed the processing node, and it is understood by the eye. This vision display may be electronic indicators, such as a flag shown to an operator or light, and an audible tone. By manual operation, a product is put on ejection from a processing setup, and he puts it on a conveyer, the operator who received this display pushes a switch by manual operation, moves a conveyer, and sends out a product to the following processing node. Therefore, if it is made the configuration automated thoroughly, although effectiveness will become good most, as for a network, manual operation may be needed in at least a part, and this invention can be adopted also in such a system.

[0050] Drawing 2 shows an example of the flow of the product passing through a semi-conductor processing network. As shown in drawing 2 , the product is held in front of the lithography node 102 at the WIP buffer (queue) 101. In drawing 2 , the signs 125-130 in drawing express the cassette of an unsettled wafer. However, the queue may hold not the wafer contained to the cassette but the wafer according to individual. A wafer moves to the lithography node 102 from the WIP buffer (queue) 101 first. However, a wafer may not restrict entering promptly to a lithography process, but there may be a maintenance bottle for receiving a wafer in a lithography node. This is a case so that the setup by an operator's manual operation may be required. In such a case, an operator will perform the setup of a wafer for a wafer in preparation for ejection and processing from a maintenance bottle.

[0051] Before going into lithography process 102B, a product (wafer) passes coat/development trace mechanism 102A. A wafer is covered with a resist at coat/development trace mechanism 102A. After being covered with a resist, a wafer goes into lithography process 102B, and is exposed there. After exposing in a lithography process, a wafer returns to coat/development trace mechanism 102A, and is developed.

[0052] After the lithography process in the lithography node 102 is completed, a wafer is sent out to the consecutiveness processing node 103 needed with the current processing pass passing through a network. A wafer should just be processed about this point by the processing node for performing implantation, measurement processing, oxidation treatment, and/or etching. Therefore, actual processing may be performed by two or more processing nodes although drawing 2 shows only one processing node 103 as a consecutiveness processing node. Those consecutiveness nodes as well as a lithography node may have the maintenance bottle for containing the product, when the setup by an operator's manual operation is required, and a product is received by the node.

[0053] If the process which follows is completed, a product (wafer) will return to the WIP buffer (queue) 101, or will be sent to the outlet process 109. A scheduler 111 judges whether a product should be returned to the WIP buffer (queue) 101, or it should send out to the outlet process 109 according to whether the wafer needs additional lithography processing and/or consecutiveness processing or processing of a wafer is completed using the trace condition explained previously.

[0054] Drawing 3 shows one of the systems which can be used for the communication link between various components which control the production line by this invention. In drawing 3 , in order to control the flow of the product in a network, a scheduler 11 is used. A scheduler 11 should just be a process step program which was embodied in the form of the computer program and electronic instrument which can process the decision in connection with the priority of the propriety of utilization of a device, the product which should be processed, and a product, or a certain means and in which computer activation is possible.

[0055] As shown in drawing 3 , the WIP tracking system 113 communicates with a scheduler 111. This communication link should just mind a certain other means of communications through direct communication, such as a wire communication or radiocommunication, through a Local Area Network as stated previously. As explained in relation to drawing 2 R> 2, the WIP tracking system 113 provides a scheduler 111 with the identification information of each product by the communication link of the WIP tracking system 113 and a scheduler 111. Then, a scheduler judges the priority of a product using this information.

[0056] Moreover, the queue process 101 is also communicating with the scheduler 111. The queue process 101 contains the product which is waiting for the processing which passes through a network. The queue process 101 provides a scheduler 111 with the information about the number of the products contained in the queue, the information about the discernment which shows which product is in a queue, and the information on others about the product in a queue. A scheduler 111 provides a queue with the directions which show that a new product should be loaded to the WIP buffer (queue) 101 from the job arrival process 100, for example while judging the priority of the product in a queue using this information.

[0057] Furthermore, a scheduler 111 emits which product of a queue from a queue, and provides the queue process 101 with the information about whether it should send out to a lithography process. Thus, a scheduler 111 and a queue 101 control the flow of the product which frequents a queue, communicating mutually.

[0058] Furthermore, the communication link with the process node 103 and a scheduler 111 is also shown in drawing 3 . The expedient top of a graphic display and drawing 3 show the communication link with one process node and scheduler 111 about this point. However, it will be thought actually that all the processing nodes in a network communicate with a scheduler 111.

[0059] Therefore, **** is expected and only one processing node is explained here. The processing node 103 communicates with a scheduler 111, and directs the timing expected as the propriety of utilization of the processing node at the event of arbitration, the change in the available condition of a processing node from a utilization impossible condition, or a processing node changing from a utilization impossible condition to an available condition. As previously stated in relation to drawing 1 B, the communication link of the condition of a processing node should just be performed through other means of a certain for transmitting change of a Local Area Network, a visual signal, or a condition.

[0060] According to this invention, it can judge whether the clear orbit of whether it returns to a queue through all the processing nodes following a bottleneck processing node by the communication link with a processing node and a scheduler or to come out from a network can be used. In order that a scheduler 111 may perform this judgment, a scheduler 111 acquires the feedback information in connection with the available condition of a processing node from a processing node. As mentioned above, a processing node offers as feedback the time frame expected as the change in

the available condition in connection with whether those processing nodes are available from information and a utilization impossible condition or a processing node becoming available at the event. a ****** [that all the processing nodes demanded in order that a scheduler 111 may process one product in a queue using this information are available in the orbit of that product passing through a network at that event] -- or it can judge when a processing node becomes available about an orbit.
[0061] Furthermore, if a scheduler 111 discovers a clear orbit about one product, the processing node in connection with the orbit will be reserved inside a scheduler 111. In order to process a specific product with the scheduler "which reserves the processing node in connection with an orbit", it is the semantics of reserving each processing node in a clear orbit. Thus, if an orbit is started, in order to process the selected product, each processing node is reserved. In order to emit directions of reservation, a scheduler 111 does not have to carry out direct communication to each processing node.
[0062] An orbit may be used promptly and time amount reservation may be carried out as stated briefly previously. namely, a clear orbit -- it can use -- the orbit -- promptly -- you may start (for example, it is not [be / it] under activity because of processing of product with an another lithography node) -- the orbit is started when a scheduler 111 judges. On the other hand, although the scheduler 111 discovered the clear orbit, since one of the nodes is processing another product for example, at the event, when an orbit cannot be started promptly, it should just carry out time amount reservation of the orbit. When "carrying out time amount reservation" and the node which cannot be used becomes [the] available, it is the semantics that an orbit can be reserved so that it can start at future ones of the events.
[0063] Furthermore, drawing 3 also shows the communication link with a scheduler 111 and a process control system 112. As previously explained in relation to drawing 1 A, one function of a process control system 112 is controlling the flow of the product which goes to another processing node from one processing node through a network. Therefore, if it becomes the time amount which should start an orbit behind when a scheduler 111 discovers a clear orbit and reserves a processing node, a scheduler 111 will issue directions so that an orbit may be started to a process control system 112, and, thereby, a process control system 112 will control the motion and processing of a product passing through a network.
[0064] Drawing 4 shows one example of the communication link between various parts of the processing network by this invention, and the flow of a product. By drawing 4 R> 4, a continuous line shows the flow of a product, and a dotted line shows a communication link by it. First, a product is held until it flows to a queue 101 and a clear orbit is discovered there, as it held in the job arrival process 100 and being previously explained in relation to drawing 1 A. About this point, a scheduler 111 is performed, as the clear orbital judging was previously explained in relation to drawing 3 . That is, the processing node 103 which follows communicates with a scheduler 111, and offers the available or impossible condition 166 of each node. If a scheduler 111 discovers a clear orbit about at least one product of a queue using the condition of a processing node, a scheduler 111 will reserve the processing node which the orbit follows.
[0065] Then, when an orbit should be started, a scheduler 111 supplies the signal 168 for starting an orbit to a queue 101. On the other hand, for example, since the clear orbit was judged based on the propriety of utilization of the processing node at the future event, when it is impossible to start an orbit promptly, a scheduler 111 transmits the signal 168 which shows when motive time amount is reached to a queue 101.
[0066] If an orbit is started, a product will flow from a queue 101 to the reentrant process 102. Also in this case, in a semi-conductor production line, a reentrant process may be a lithography process. If the reentrant process 102 completes processing of a product, a product will flow to each of the consecutiveness processing node 103 needed in order to process the product. By drawing 4 , in order to simplify, the processing node 103 which follows is shown as one process. However, the processing nodes 103 which follow may be multiple processes like the case of explanation of drawing 2 .
[0067] After being processed by the processing node 103 which follows, according to the orbit judged about the product by the scheduler 111, it is decided how a product will flow. In case a clear orbit is judged about this point, a scheduler 111 judges whether it should return to a queue for an orbit's additional processing of a product, or the product is completed.
[0068] Whenever one product is completed, in order to pursue the number of processing pass, a scheduler receives feedback information from a WIP trace mechanism, as previously explained in relation to drawing 3 . A scheduler 111 can judge whether a product is completed after whether it is the last pass with which the present orbit passes along a network, and its pass, or the product needs additional processing using this information. When a scheduler 111 judges with an orbit being the last pass after being processed by the processing node 103 which follows, a product flows to the outlet process 109. On the other hand, when a scheduler 111 judges with the orbit needing additional processing, as for not the last pass but a product, a product returns to a queue 101, after being processed by the processing node 103 which

follows.

[0069] Drawing 5 is a flow chart which shows the process step program for controlling the production line by this invention. The process step program of drawing 5 should just be embodied as a certain means of the others which can operate a computer program, electronic instruments, or those process step programs. It reads by computers, such as the scheduler 111 of drawing 1 A, and it is desirable to store a process step program in the medium in which computer reading is possible so that it can perform.

[0070] If it says simply, a process step program will perform a clear orbital judging, will reserve the processing node in connection with a clear orbit, and will start an orbit.

[0071] A process starts by loading a product to the queue of a reentrant process. As shown in drawing 5 , at step S501, it judges whether a queue is full. This judgment makes it connected with a number of a product of fixed limitations which can exist in a queue at the event of arbitration, and may be performed by taking into consideration the property of queues, such as the number of the products in the instant size of a queue, i.e., a queue.

[0072] For example, a fixed limitation is assigned to a queue based on the maximum number of the product which can hold a queue. A process judges the number of the products in a queue, and compares it with a fixed limitation. When judgment that a queue is full is made, flow progresses to step S503. On the other hand, when judgment that a queue is not full is made, it is step S502 and a new product is added to a queue. A new product is added to a queue until the size of a queue exceeds a fixed limitation. When a fixed limitation is arrived at, count of the orbit about the product of a queue is performed so that it may explain further below at a detail.

[0073] Orbital count relates to some steps which contain S505 from step S503. At step S503, which processing node judges whether it is in an available condition so that drawing 5 may show. The method of performing this judgment is considered variously. For example, in order to judge whether each processing node is available, a repetitive porin group may be performed with a scheduler. Or as previously stated in relation to drawing 3 and drawing 4 , each processing node may provide a scheduler with feedback information periodically about the condition of the propriety of the utilization. In order to direct the propriety of utilization, it is not concerned with which approach is used, but a judgment process continues until at least one processing node becomes available.

[0074] If at least one processing node becomes available, the processing node which is in an available condition will be classified based on the priority in a processing network, respectively (step S504). For example, being needed for processing rather than any of other nodes may classify a processing node based on which node it is. As an example, the case where both the processing nodes 103 and 104 of drawing 1 C are available is considered. In a processing network, the product which needs processing by the processing node 104 must be first processed by the processing node 103.

[0075] Therefore, since the processing node 103 must be used first, priority higher than the processing node 104 is given to the processing node 103. A scheduler classifies a processing node based on the priority of those processing nodes in a processing network whenever the directions about when each processing node will be in an available condition whenever one processing node becomes available are issued.

[0076] After classifying an available processing node, it judges which product has consistency in an available processing node among the products contained in a queue (step S505). That is, it judges whether a processing node available for the processing in the following pass whose product of which passes along a network among the products of a queue is needed.

[0077] For example, suppose that the processing nodes 103 and 104 are available. Adjustment is found out when processing only by the processing node 103 and/or the processing node 104 is being demanded with the following pass one which is contained in a queue of whose products passes along a network. However, although the processing nodes 103 and 104 are available, since the processing node 106 cannot be used when processing by the processing nodes 103, 104, and 106 is being demanded with the following pass each product of whose of a queue passes along a network, adjustment is not found out.

[0078] As mentioned above, this invention discovers the clear orbit through all the processing nodes demanded in order to process the selected products including a reentrant processing node with the following pass passing through a network. Therefore, adjustment will be found out if at least one of the processing nodes demanded in order to process the selected product cannot be used. When adjustment is found out, flow progresses to step S506. However, when adjustment is not found out, a porin group is performed again and the classifications of an available processing node based on priority including the processing node considered to have become available after the previous porin group are repeated.

[0079] Also in this case, the judgment for adjusting an available processing node with the product in a queue at step S505 is performed. When a porin group continues until adjustment was found out, and adjustment is found out, flow progresses to step S506. When at least one adjustment is found out, the product of a queue with which adjustment was

found out is classified according to step S506 based on the priority. That is, when two or more adjustment is found out, a scheduler assigns priority to each product with which adjustment was found out. This priority may be based on which product is the closest to completion, i.e., which product is the closest to a network outlet?.

[0080] Then, it chooses about the orbit which passes along each of the processing node demanded in the product which has the highest priority in order to process the product with the following pass (S507), and returns to a queue, or takes out from a network.

[0081] After a product is chosen about an orbit at step S507, at step S508, the processing node demanded in order to process the selected product is reserved about the orbit. A scheduler reserves each processing node in connection with the orbit of the product chosen in the interior. A processing node may be reserved about an orbit instancy and time amount reservation may be carried out about an orbit. It is decided by whether it becomes available about an orbit by (t) at the event of whether in order for whether an orbit is used immediately or time amount reservation is carried out to start the orbit, a processing device can be used promptly, and either of the futures [device / processing].

[0082] Next, priority is given to a reentrant processing node at step S509. A reentrant processing node may give priority based on the result of a request. For example, two or more lithography equipments are contained in the network, and in order that each equipment may process the specific layer of a wafer, the case where the 1st is specified is considered. In this case, it is desirable to give priority to the equipment which will bring about the best result.

[0083] However, the equipment which has the highest priority is not always chosen. For example, although one equipment of other will perform a process when desired equipment cannot be used, the result is inferior to the result of a request.

[0084] At step S510, it judges whether the setup process in connection with one of reentrant processing nodes or its reentrant processing node itself is available. If either the setup process of one of reentrant nodes or a reentry process can be used, the orbit of the product chosen at step S511 will be started. When a setup process or a reentry process cannot be used, a porin group is performed again.

[0085] After starting the orbit of the product chosen at step S511, a process judges the number of the products in return and a queue again to step S501. Next, control of the specific product according to the orbit shown in drawing 1 C is explained.

[0086] In relation to this explanation, all the wafers of a queue are waiting for the 1st processing pass, namely, it is assumed that the product is not processed yet. Furthermore, it is assumed on the both sides of the time [1st] pass passing through a network, and time [2nd] pass that each wafer should be processed by the processing nodes 103, 104, 106, and 108, respectively.

[0087] When starting processing, the batch of the wafer contained by the cassette is first loaded to the job arrival process 100. For example, what is necessary is just to load cassettes 125-130 to the job arrival process 100, as shown in drawing 2 . Generally a wafer batch is loaded by the operator by manual operation.

[0088] When it returns to drawing 1 C, it is loaded in wafer batch from the job arrival process 100 until the number of sheets of the wafer with which the WIP buffer (queue) 101 is loaded to a queue using steps S501 and S502 of drawing 5 reaches a predetermined limitation, for example, ten batches. The process of this loading should just be controlled by the process control pin center,large 112. If the number of the loaded wafer batches reaches a limitation (10), it will be ordered the process control pin center,large 112 so that the job arrival process 100 may be made to stop loading of the wafer batch to a queue 101.

[0089] A scheduler 111 judges whether the clear orbit which passes along all processing nodes, and returns to a queue 101 about each of ten wafer batches of a queue 101, or comes out of a process 109 exists. As stated previously, a scheduler 111 receives the feedback information about the condition of the propriety of the utilization from each processing node 103-108.

[0090] It is not, and no processing nodes are under activity, therefore assume that all processing nodes are available in this example. Therefore, except for the wafer in a queue 101, the wafer does not exist in a network. Therefore, since each wafer of a queue 101 is in the condition of waiting for the time [1st] processing pass passing through a network, it judges whether a scheduler 111 has the available processing nodes 103, 104, 106, and 108 for every wafer.

[0091] As mentioned above, the processing nodes 103, 104, 106, and 108 are nodes needed in order to process a wafer with time [1st] pass. If it judges with those processing nodes being available, a scheduler 111 will judge whether a clear orbit can be used about each wafer in a queue 101.

[0092] The next step of processing is a step which judges which wafer in a queue 101 a scheduler 111 should choose to a clear orbit. As previously explained in relation to drawing 5 , priority is given to a wafer based on the number of the processing steps demanded in order to complete processing.

[0093] However, in this example, since all wafers are in the condition of waiting for time [1st] processing pass, all

wafers have the same priority. Therefore, a scheduler 111 chooses one sheet of the arbitration in ten wafers by choosing the wafer probably loaded to the beginning by the queue 101 from the ** job arrival process 100 on the occasion of processing.

[0094] If a scheduler 111 chooses one wafer about a clear orbit, a scheduler 111 will reserve the processing nodes 103, 104, 106, and 108 (processing node demanded in order to process the wafer chosen in the time [1st] current pass passing through a network).

[0095] If a processing node is reserved, a scheduler 111 will judge whether the bottleneck processing node 102 can be used about an orbit instancy. Since there is no wafer currently processed according to the bottleneck process 102 in this example at that event, it is possible to use an orbit instancy. Then, a scheduler 111 transmits a signal to a queue 101 and the process control pin center,large 112, in order to emit the selected wafer and to send it out to the bottleneck processing node 102 (lithography).

[0096] Next, the process control pin center,large 112 operates a queue 101, a conveyer 104, the gate 115, etc., and in order to move the selected wafer to the processing node 102, it starts control of processing.

[0097] Before going into the processing node 102, a wafer may pass the trace mechanism 113. The trace mechanism 113 may be a scanner which gets to know the serial number of the wafer by scanning the bar code of a wafer. Then, the trace mechanism 113 provides a scheduler 111 with the identification information of a wafer. A scheduler 111 assigns priority for every wafer of a queue using this information as stated previously.

[0098] As mentioned above, the bottleneck processing node 102 may need the setup by an operator's manual operation. However, in this example, the setup is automatic, and when the processing node 102 is reached, a wafer is set up automatically and assumed to be that from which a lithography process begins.

[0099] After the 1st wafer begins to be processed, a scheduler 111 calculates a clear orbital judging about each of the wafer which remains in the queue 101. In this case, since the processing nodes 103, 104, 106, and 108 are reserved, when a scheduler 111 judges [that those nodes cannot be used and], a scheduler 111 will not find out a clear orbit about every product of a queue.

[0100] However, each processing node 103, 104, 106, and 108 issues directions that those nodes become available at time amount (t) to a scheduler 111. Therefore, a scheduler 111 can find out a clear orbit to time amount (t) for every wafer of a queue 101. In this case, time amount reservation of the clear orbit is carried out. That is, a reservation signal is transmitted to each of the processing node in connection with the 2nd wafer chosen about the orbit so that each processing node may be reserved by time amount (t) about the orbit of the 2nd wafer. Therefore, if time amount (t) is reached, a scheduler 111 will transmit a signal to a queue 101, in order to start the orbit of the 2nd wafer, when the processing node 102 becomes available.

[0101] The above-mentioned process is continued a scheduler 111 calculating a clear orbital judging for every wafer of a queue. However, if the 1st wafer returns to a queue following completion of the 1st processing pass, a scheduler 111 will calculate a clear orbital judging again about the wafer of a queue including the 1st wafer. This situation is explained further below at a detail.

[0102] If the 1st wafer returns to a queue 101, a scheduler 111 will calculate a clear orbital judging the same with having explained previously. However, if the clear orbit is found out about two or more wafers of a queue 101, a scheduler 111 will reserve the orbit about the wafer which has the highest priority. In the case of this example, the 1st wafer has completed one processing pass, but no remaining wafers of a queue 101 are processed at all.

[0103] Therefore, before a scheduler 111 assigns high priority with the 1st wafer, consequently reserves a clear orbit about the low wafer of priority from it, it reserves a clear orbit about the 1st wafer. Therefore, if the processing node 102 will be in an available condition, a scheduler 111 will transmit a signal to a queue 101, in order to start an orbit about the 1st wafer.

[0104] A scheduler communicates with various processing devices of a network 125, consequently controls the flow of the product in a processing facility so that the above example shows easily. Usually, processing of the product of a queue is not started until a clear orbital judging is found out and a processing node is reserved about the orbit. Therefore, the secondary bottleneck in a processing network is avoided substantially. Moreover, since a still more suitable loading schedule is prescribed by the scheduler, utilization of a bottleneck process is also improved greatly.

[0105] This invention was explained about the specific example. This invention is not limited to an above-mentioned example, but he should understand that various modification and deformation can be carried out without deviating from the meaning of this invention by this contractor.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1 A] Drawing showing the multi-node processing network by this invention.
[Drawing 1 B] Drawing showing the communication link between the components of the processing network of drawing 1 A.
[Drawing 1 C] Drawing showing one processing orbit which can be considered as a processing orbit of the product passing through the network of drawing 1 A.
[Drawing 2] Drawing showing one example of the flow of the product passing through the processing network by this invention.
[Drawing 3] Drawing showing the communication link between various parts of the processing network by this invention.
[Drawing 4] Drawing showing the flow of the product between the processing nodes by this invention, and a communication link.
[Drawing 5] The flow chart which shows processing of the process step program by this invention.
[Description of Notations]
100 [-- A processing node, a 109 outlet process, 111 / -- A scheduler, 112 / -- A process control pin center,large, 113 / -- A product trace mechanism, 114 / -- A conveyer, 115 / -- The product flow gate, 125 / -- A processing network, 130 / -- A multi-node processing network, 150-155 / -- A computer, 250 / -- Communication network] -- A job arrival process, 101 -- A WIP buffer (queue), 102 -- A bottleneck processing node, 103-108

[Translation done.]

DRAWINGS

[Drawing 1 A]

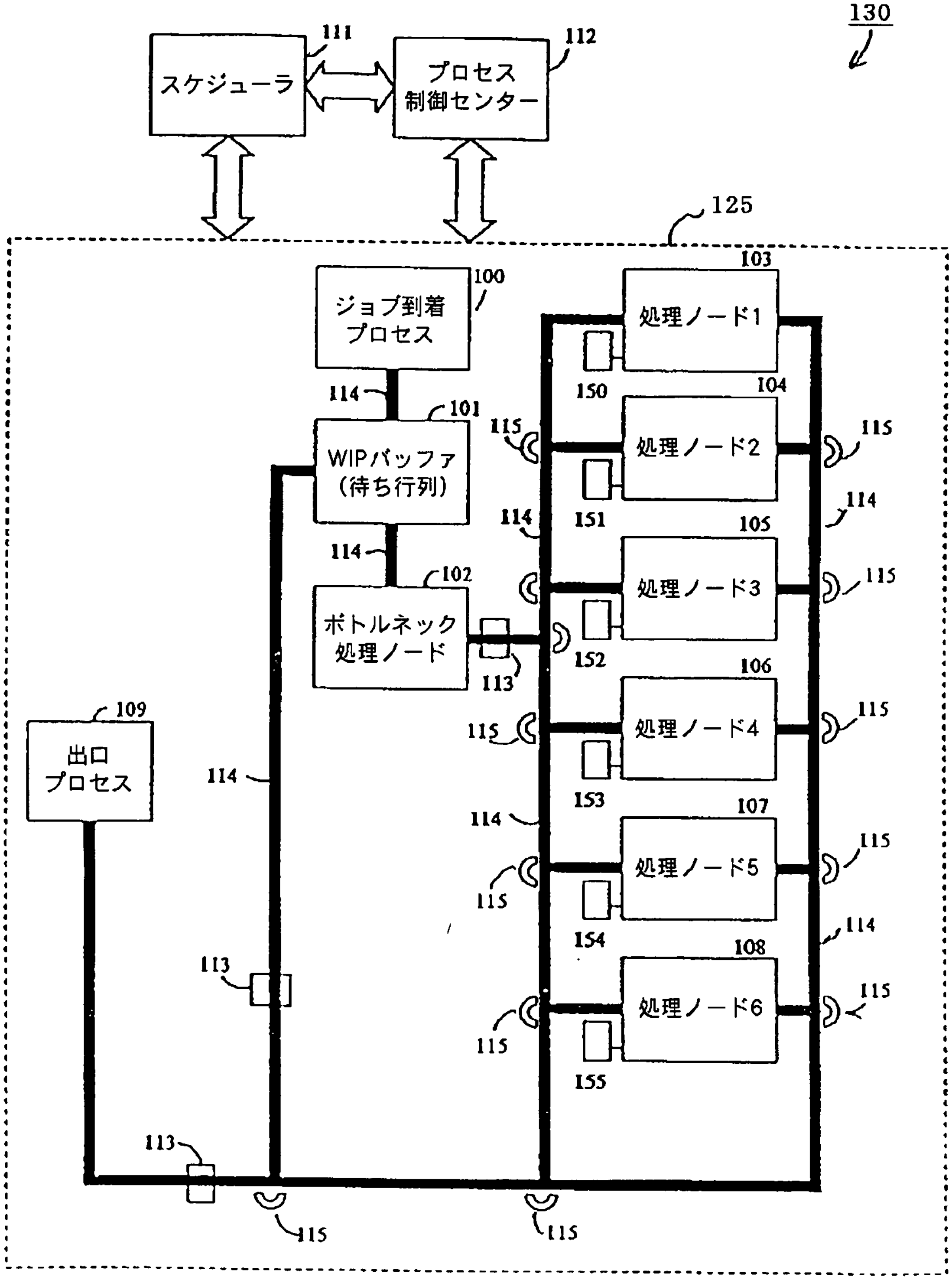

FIGURE 1A

[Drawing 1 B]

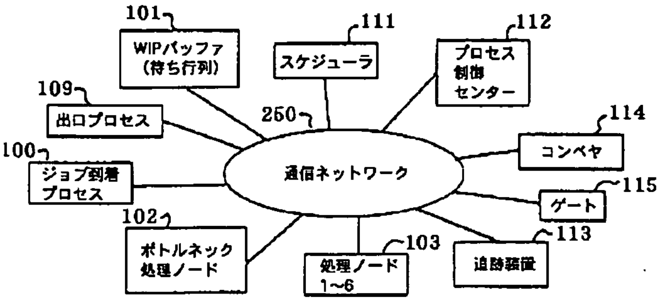

FIGURE 1B

[Drawing 2]

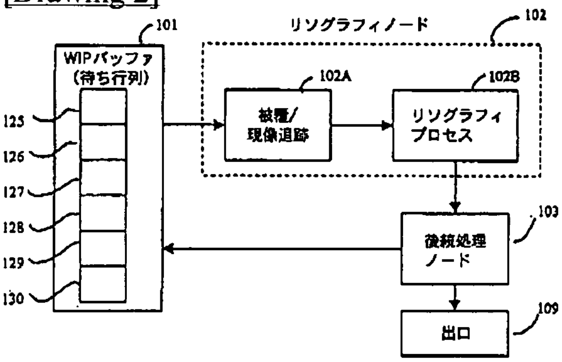

FIGURE 2

[Drawing 3]

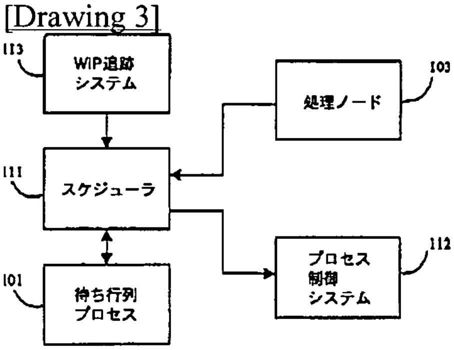

FIGURE 3

[Drawing 4]

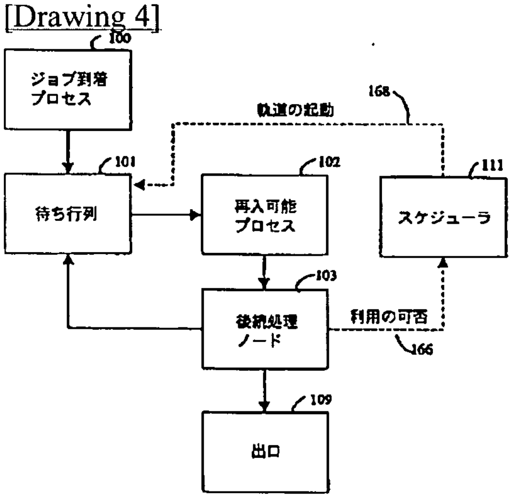

FIGURE 4

[Drawing 1 C]

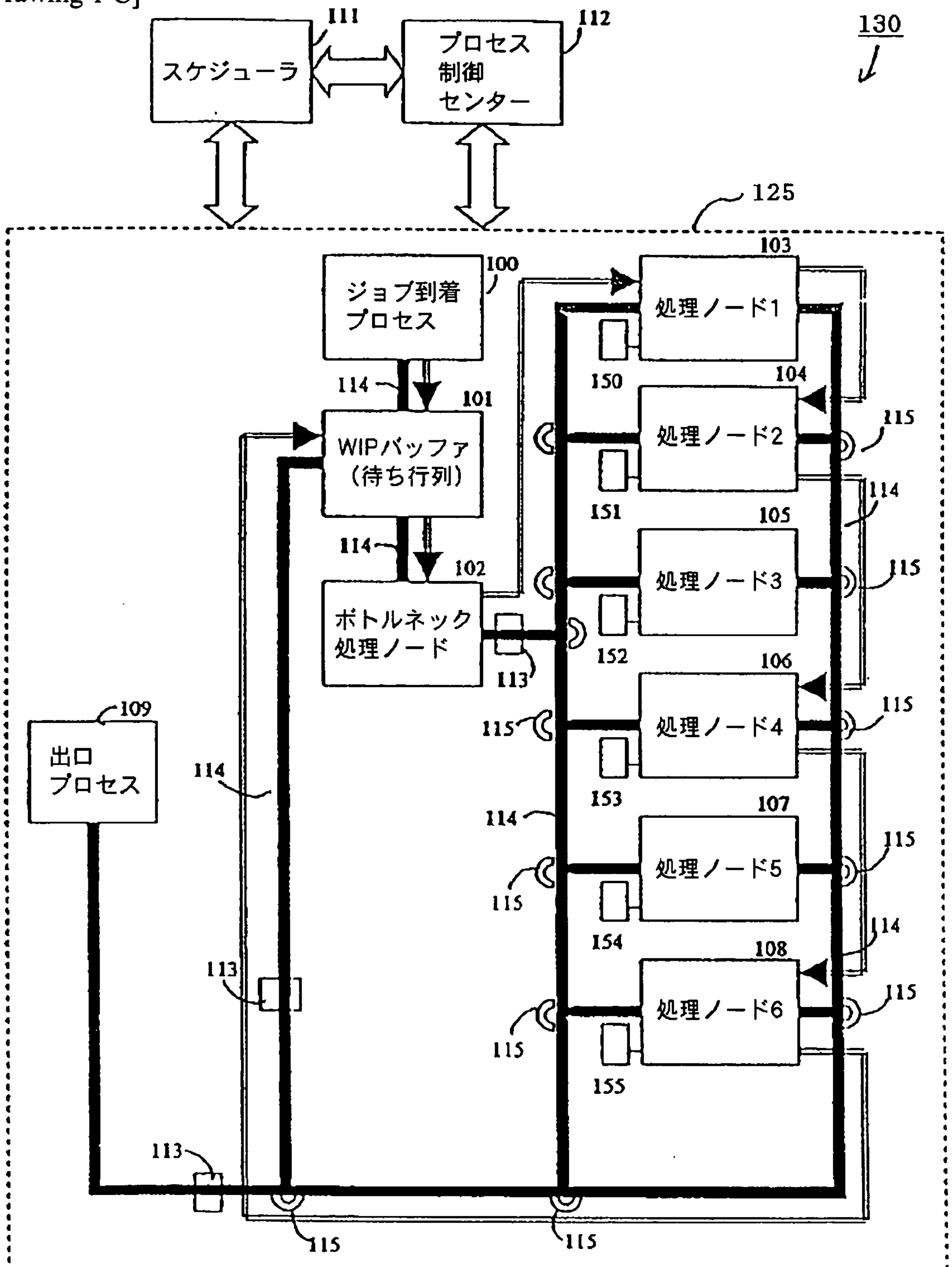

FIGURE 1C

[Drawing 5]

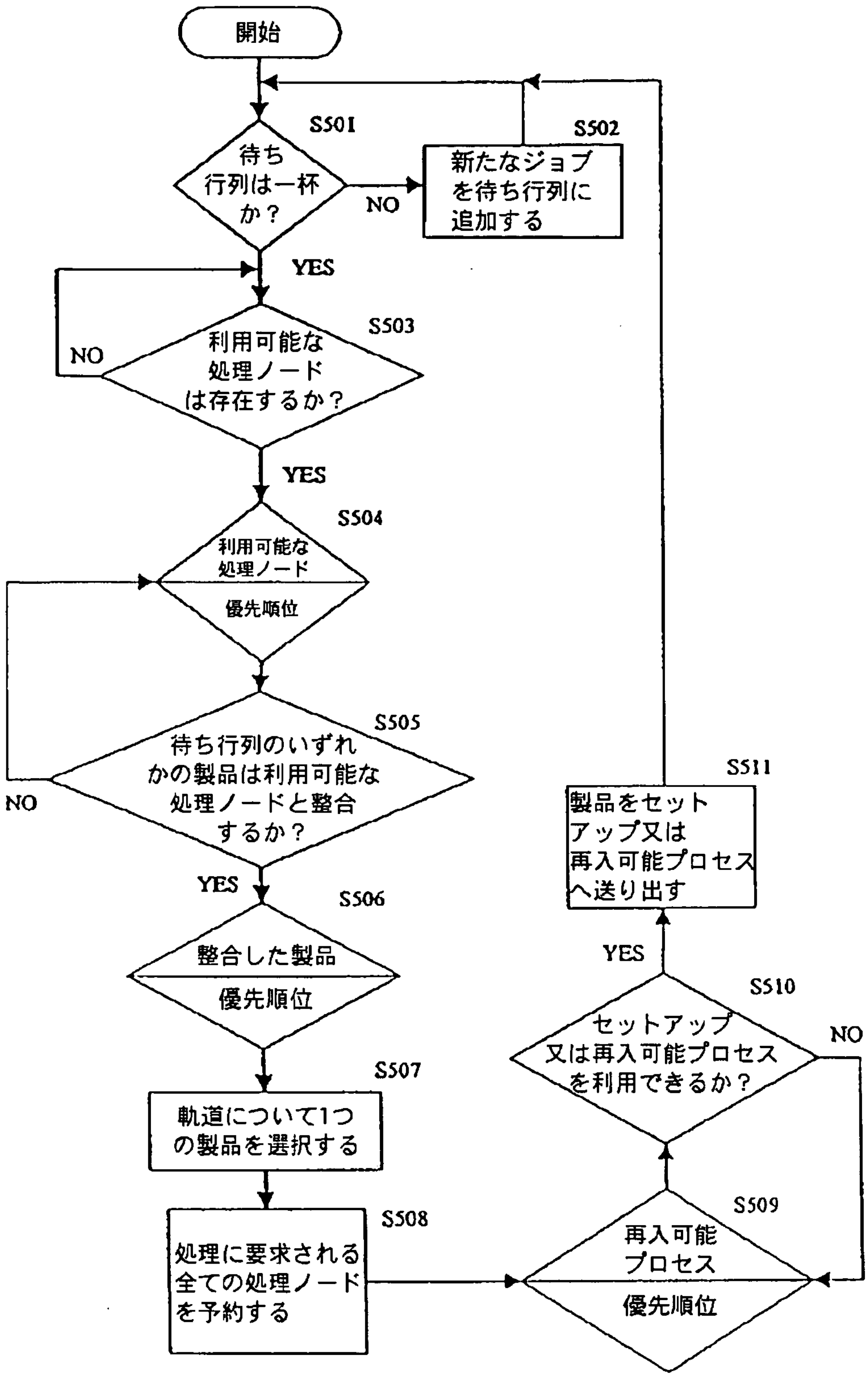

FIGURE 5

[Translation done.]